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Business cycles and monetary policies in a small open emerging economy

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Preface

Cette thèse est l'aboutissement d'un long cycle. Parfois difficile et incertain, il fût rempli de bon moments et d'opportunités. Je n'oublierai jamais ce que j'ai appris et les rencontres que j'ai pu faire au cours de ma thèse.

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Introduction

Developing and emerging economies often face large business cycle shocks - such as commodity term of trade shocks - exacerbated by incomplete financial markets. These specificities generate strong business cycle fluctuations accompanied by large detrimental welfare effects. [1] Demand management tools such as monetary and fiscal policies could therefore ease this burden by effectively mitigating aggregate volatility. A prerequisite for implementing appropriate stabilisation policies is to build a structural model capable to explain macroeconomic fluctuations. This in turn requires a profound understanding of the specificities driving the business cycle. This thesis describes the domestic and external driving forces behind business cycle fluctuations in developing and emerging countries. It then presents a Dynamic Stochastic General Equilibrium (DSGE) model capable to explain the transmission mechanisms of these shocks. Within this framework, it measures the welfare cost of business cycles fluctuations for different types of agents that are included or excluded from the financial markets. Finally, it assesses the efficiency of a number of monetary policy rules such as inflation targeting or output and exchange rate stabilisation.

Some clarifications can help to refine the scope of this thesis. First, the analysis is restricted to small open commodity exporters - which include many developing and emerging economies - but does not directly apply to net commodity importers or large economies such as China.[2] Second, the opening chapter performs a business cycle analysis for developing and emerging countries. However, the structural model designed in subsequent chapters focuses on emerging countries. The estimation of low income countries DSGE models is challenging.[3] This thesis takes a first step towards a gradual approach to this issue. Indeed, by exploiting some common specificities of developing and emerging countries, the results presented in this thesis could be used as an input to estimate a model on a low income country. Third, even though fiscal

[1] There is an import body of literature describing business cycles in developing economies: Agenor et al. (2000), Rand and Tarp (2002), Male (2011) and emerging countries: Neumeyer and Perri (2005), Aguiar and Gopinath (2007) and Garcia-Cicco et al. (2010). Moreover,Pallage and Robe (2003) and Houssa (2013) show that the welfare cost of business cycles could be large in these countries.

[2] UNCTAD (2016) considers 91 developing countries as "commodity dependant". They include all countries with a commodity exports to total merchandise exports ratio above 60% for the 2014-2015 period.

[3] See Houssa et al. (2010) for a discussion on the difficulty to identify parameters in an estimated DSGE model applied to a low income economy.

policy is an important side of demand management, this aspect is not covered in this work.[4] Fourth, this thesis analyses business cycles. Although structural breaks and reforms - such as drastic changes in political environments or in monetary policies - are important aspects in developing and emerging economies, they are beyond the scope of this thesis. These considerations however directed the choice of the two countries and timespan on which the model is applied. Finally, the empirical analysis focuses on the cases of Ghana and South Africa but the models developed in this thesis could be tested on other small open developing and emerging economies.

The remainder of this introduction is organised as follows. It begins with the description of the economic structures of Ghana and South Africa and justifies their use in the course of this thesis. It then turns to the stylised facts described in chapter one. It follows with a short presentation of the DSGE model and the structural business cycle analysis constructed in chapter two. Finally, it summarises the welfare effects of business cycles and monetary policies proposed in chapter three.

A note on Ghana and South Africa The empirical business cycle analysis in chapter one uses data from Ghana and South Africa. The structural model developed in chapter two and three is based on the South African economy. Some time is therefore devoted to explain these choices and to provide a background on those economies.

A first condition to perform a business cycle analysis is a minimal level of political and economic stability. In South Africa, after wining the elections in 1948, the Afrikaner National Party imposed a set of reforms enacting the Apartheid into law. They comprised separation based on the race preventing contact between the different groups as well as exclusion from the political spheres, limited economic opportunities and land grabs touching the non-whites. The Apartheid triggered years of protests, strikes and repression. The international community imposed sanctions on the Apartheid regime[5] and foreign banks and firms were discouraged by the weak economic outlook. Political and economic pressures at home and abroad finally forced the government to negotiate. The Apartheid period officially came to an end with the introduction of a new constitution in 1994. South Africa has since then enjoyed a period of political and economic stability. Ghana became independent from Britain in 1957. However, political instability resulting from years of military rules only ended in 1992 with the introduction of a new constitution establishing a multi-party democracy. Economically, the early 1980s period was also erratic, with large internal and external deficits, limited foreign exchange reserves, high inflation, overvalued exchange rate, a severe drought and negative economic growth. The situation then gradually improved and growth returned in the mid-1980s.

Second, South Africa and Ghana are representative of other emerging and developing small

[4] The interested reader is refered to Ratto et al. (2009) for a model with monetary and fiscal policies.

[5] See for e.g. Levy (1999) for a review of those sanctions and their impacts.

open commodity producers. South Africa is classified as an upper-middle income country by the World Bank and is considered as an emerging economy by the IMF. Its GDP represents less than 0.5% of world GDP.[6] Ghana is classified as a lower middle income developing economy and its GDP is lower than 0.1% of world output. These countries are therefore arguably small enough to fit a crucial assumption in Small Open Economy (SOE) models, namely that their impacts on world markets are small enough to be ignored. South Africa and Ghana are also well integrated in world trade and financial markets. Indeed, South Africa and Ghana have a trade (defined as the sum of exports and imports) to GDP ratio of 60% and 88%, respectively.[7] These numbers are larger than the average of 36% observed for the group of BRIC countries. Moreover, Lane and Milesi-Ferretti (2007) financial openness measure (for the year 2011) shows that the sum of external assets and liabilities to GDP ratios in South Africa (159%) and Ghana (86%) compare to other BRIC countries (96%, on average). Finally, Ghana and South Africa are dependent on commodities. In South Africa, primary commodities account for about 55% of merchandise exports while this number is as high as 94% in Ghana during the 2014-2015 period.[8] South Africa exports fuels and metals such as coal, aluminium, platinum, silver, gold and diamonds. Ghana mainly exports cocoa and gold as well as oil since 2010.

A third condition relates to the availability and quality of data. South Africa is one of the very few emerging market which possesses a large panel of macroeconomic series at quarterly frequency, allowing to consider advanced estimation methods. For Ghana, as for most developing countries, data poses a challenge. For example, quarterly GDP observations are only available since 2006. In the empirical analysis, data have been reconstructed.

South Africa and Ghana also share a similar evolution of monetary policy.[9] Prior to 1981 the South African Reserve Bank (SARB) operated under a liquid assets based system. This period was characterised by exchange rate controls and financial repression. The SARB then entered a transition period. Interest rates and credit ceilings were abolished. Exchanged rates controls were progressively relaxed and a managed float was introduced in 1983. However, some form of exchange rate controls were quickly reintroduced in the 1985-1995 period following political and economic instability. From 1986 to 1998, the SARB used a cash-reserve based system with pre-announced monetary targets primarily aimed at combating inflation. Monetary policy was relatively opaque and the SARB progressively moved to an eclectic approach using a set of indicators including the exchange rate and the output gap (Aron and Muellbauer (2006)). The end of the Apartheid period then led to more financial openness and liberalisation. In 1998, the SARB mainly operated under a repo system. The SARB managed daily tenders of liquidity

[6]Data from the International Monetary Fund.

[7]Data from the World Bank for the year 2016.

[8]Data from UNCTAD, state of commodity dependence.

[9]See Mollentze (2000), Aron and Muellbauer (2002) and Muyambiri and Odhiambo (2014) for a description of the evolution of monetary policy in South Africa. Also see Sowa and Acquaye (1999) and Abradu-Otoo et al. (2003) for more information on Ghana.

through repurchase transactions where the repo rate was set at an auction. This system paved the way to the introduction of inflation targeting in 2000. The SARB currently aims for a range of 3 to 6 per cent for the year-on-year increase in the headline CPI on a continuous basis. The SARB conducts its main refinancing operation - called the weekly seven-day repurchase auction - with commercial banks. The repo rate - set by the Monetary Policy Committee - determines the rate at which the SARB lends funds to the banks against liquid assets. This later change in regime coincides with the decision of other emerging countries to abandon exchange rate targeting in favour of inflation targeting after the wave of currency crisis in the 1994-2001 period.[10] The evolution of monetary policy in Ghana is similar. In 1983, monetary policy switched from a direct control of credits and interest rates to a monetary targeting regime. It also marks the beginning of a liberalization of the exchange rate. Full liberalization was achieved in 1990 when for the first time the exchange rate was set in the inter-bank market. In 2001, the Bank of Ghana started the transition to inflation targeting regime, which was formally adopted in 2007. The Bank of Ghana aims for a medium term inflation rate between 6 and 10 percent and uses its policy rate as main instrument. In this context, a Taylor rule could provide a good description of monetary policy in Ghana and South Africa.

South Africa and Ghana are however very different regarding the developments of their financial sectors. On the one hand, South Africa has a well developed banking sector. Domestic credit to the private sector fluctuated between 100 and 160% of GDP in the post-Apartheid period and amounts to 145% of GDP in 2016 (versus 91% on average in the BRIC group).[11] In addition, South Africa is integrated in the world financial markets. Foreign banks are active in South Africa. The share of foregn banks assets among total bank assets in South Africa is similar to that of other OECD countries. Indeed, Claessens and Horen (2014) estimate this share to 22% in 2006 in South Africa (compared 27% for the OECD group and only 9% on average in other BRIC countries). Despite the relative development of the credit market in South Africa, many households are financially excluded. Indeed, 30% of the South African population (over 15 years) has no account at any financial intermediary compared to 9% in advanced countries.[12] On the other hand, Ghana has a less developped banking sector. Domestic credit to the private sector peaked at a low 20% of GDP in 2015 and Claessens and Horen (2014) estimate that the share of domestic banks assets among total bank assets is just above 40%. Similarly to many developing countries, financial exclusion is widespread: only 35% of adults have an account at a financial institution and less than 6% of adults use their account to receive their wages.

[10] See Frankel (2011) for a survey on monetary policy in emerging countries.
[11] World Bank.
[12] World Bank Financial Inclusion Database.

Chapter one *"The Sources of Business Cycles in a Low Income Country"* is a joint paper with Romain Houssa and Christopher Otrok.[13] It documents the driving forces of business cycles in a developing country (Ghana) compared to a similar emerging economy (South Africa).

In a first stage, we identify domestic and foreign credit and productivity shocks using sign restrictions in a Bayesian Vector Autoregression (VAR) model.[14] The VAR includes domestic (Ghana or South Africa) and foreign (G7) variables over the 1985-2010 period. We distinguish between domestic and foreign sources of fluctuations by assuming that domestic shocks have no impact on global variables. The credit shock is an exogenous shock to the supply of credit. We impose that this shock generates a drop in real credit, an increase in the spread and does not lead to an increase in the default rate in order to isolate this pure credit supply shock from the endogenous response of credit to fundamental macroeconomic shocks. The productivity shock provokes a drop in output and credit and an increase in inflation and default rates. In a second stage, we identify commodity price shocks in a Bayesian VAR including domestic variables and commodity prices assuming that commodity prices are exogenous to development in South Africa or Ghana.[15]

We find that global productivity and credit shocks have a greater impact on South Africa than in Ghana. The fact that global credit market shocks do not affect Ghana while productivity shocks do is suggestive that Ghana's integration with the world is more through trade channels, and less through financial channels. Domestic versions of both shocks highlight a key difference between South Africa and Ghana in that monetary policy in Ghana has responded more strongly to inflation than drops in output. Finally, we find that commodity shocks are an important driver in business cycles in both countries. This result highlights the importance of a primary goods sector in developing a model for business cycle stabilization in South African or in Ghana. In contrast, shocks traditionally emphasized in advanced economies (productivity, credit) play a more muted role. The subsequent chapters draw on these results to build a model for business cycle and monetary policy analysis in South Africa.

Chapter two *"Empirical Framework for Macroeconomic Policies in Emerging Markets"* is a joint work with the same co-authors. In this paper we build and estimate a SOE-DSGE model that is capable to explain the relative roles of external and domestic factors in macroeconomic fluctuations in an emerging market.

We extend Adolfson et al. (2007)'s small open economy model in a number of dimensions that are empirically relevant to understand the transmission mechanisms of structural shocks originating from advanced countries (foreign block) to an emerging economy (domes-

[13] This chapter draws on Houssa et al. (2013). This earlier work describes the sources of business cycle fluctuations in South Africa.

[14] The methodology follows Uhlig (2005) and Mountford and Uhlig (2009) to implement sign restrictions as well as Helbling et al. (2011) and Meeks (2012) to identify credit supply shocks.

[15] The methodology follows Mendoza (1995) and Broda (2004) to identify commodity price shocks.

tic block). First, the economy is populated by three types of households: savers, entrepreneurs, and rule of thumbs households that are excluded from financial markets.[16] Second, firms in the domestic and foreign blocks produce primary commodity and secondary products that are both traded. Commodity prices are endogenously determined in the foreign block where they are used as inputs in the secondary good production process. Third, we introduce a financial sector comprising domestic and foreign banks.[17] Banks collect deposits and provide loans to entrepreneurs and firms. Foreign banks operate in the domestic and foreign markets and propagate the developments in the foreign credit market to the domestic economy. Monetary policy is modelled as Taylor rule with interest rate smoothing and responds to CPI-inflation deviation from target, to the GDP growth rate and to changes in the nominal exchange rate. We estimate the model with Bayesian methods using quarterly data from G7 countries and South Africa over the period 1994Q1 to 2016Q1 and we identify a variety of domestic and foreign shocks. They comprises supply, demand, credit, monetary, and commodity supply shocks.

Results show that the extended model is capable to replicate the quantitative importance of domestic and foreign shocks described in chapter one. In particular, foreign (demand, supply, monetary policy, credit supply, and commodity supply) shocks are important drivers of macroeconomic fluctuations in South Africa. For instance, they explain about 25% of the variability in real activity in South Africa. Historical decomposition also highlights their specific roles during key episodes such as the 2007/08 financial crisis and the commodity price slump in 2015. Finally, we examine more precisely the transmission channels of foreign shocks in South Africa. By shutting down some channels one at a time, we find that primary commodity plays an important role in the transmission of foreign shocks and that the credit channel has contributed to amplifying the fluctuations caused by those shocks. These results support the view that commodity prices are important driver of economic fluctuations in small open emerging economies (e.g. Mendoza (1995) and Kose (2002)). We argue that endogenous commodity price helps to replicate business cycles synchronization between G7 countries and South Africa. For instance, a positive demand G7 shock would stimulate the demand for commodity, which implies a rise in commodity price and in turn generates a boom in South Africa.

Chapter three *"Welfare effects of business cycles and monetary policies in a small open emerging economy"* is the final chapter of this thesis. This paper draws on the model presented in the second chapter to measure the welfare cost of business cycle fluctuations and the effects monetary policies. The model therefore captures the key characteristics of a typical small open emerging economy: a large commodity sector exposed to developments in world commodity prices and imperfect capital and financial markets limiting the ability of some households to smooth consumption inter-temporally and to insure against idiosyncratic risks in the labour

[16]Rule of thumbs householdsare similar to Mankiw (2000).

[17]Our financial sector draws on Gerali et al. (2010) and Kollmann (2013).

market. Two alternative assumptions are considered to reproduce a link between business cycle fluctuations and idiosyncratic risks in the labour market: monopolistic competition with Calvo wage rigidities developed in Erceg et al. (2000) and search and matching frictions with staggered wage bargaining following Gertler and Trigari (2009) and Thomas (2008).

In this context, the welfare costs of business cycles are substantial in the emerging economy and they are much larger for households excluded from financial markets. Most of this welfare gap is driven by the exclusion from the insurance market. Moreover, option effects allow financially included households to benefit from some business cycle fluctuations - such as foreign commodity supply shocks - while it is unlikely to be the case for the other type of agents. This study also decomposes the welfare costs of business cycles into different types of disturbances classified according to their nature (demand vs supply) and origin (domestic vs foreign). It reveals that both domestic demand and supply shocks have important welfare effects hinting that there could be scope and limitation for more aggressive demand management policies. Foreign shocks also have economically meaningful welfare effects.

This paper then explores potential welfare gains from simple monetary policy rules to draw relevant policy recommendations. The welfare gains from a more aggressive anti-inflation policy are very important and robust to parameter uncertainty. Responding to output fluctuations is more likely to benefit excluded households. The optimal rule depends on the structure of the labour market. In the staggered monopolistic wage setting environment, the optimal policy consist in a immediate and strong response to inflation deviation from its target. In the search and matching friction with staggered wage bargaining framework, included households would benefit from a moderate response to output, while excluded households would prefer to place a large weight on output in addition to the strong anti-inflation stance. Although financially excluded households gain more from appropriate stabilisation policies, the welfare costs of business cycle remain substantial, especially for this category of agents.

Chapter 1

Sources of Business Cycles in Developing and Emerging Countries

1.1 Introduction

Developing policies for stabilizing macroeconomic fluctuations has been the subject of many papers in both advanced and emerging markets. A prerequisite for building the structural models to develop these policies is knowledge of the main sources of fluctuations in these economies. In this paper we take the first step towards developing stabilization policies in a low income country by documenting the driving forces of fluctuations in this type of economy.

Empirical work for low income countries has unique challenges. First, data is typically of poor quality and the time series length short relative to more advanced economies. Second, the economic structure of these economies is typically quite different from more advanced economies. In this paper we address the data issue by constructing our own time series for GDP. This allows us to create longer time series than is available historically. We take a first pass at issue two by studying a more advanced economy with a similar production structure.

In our case we study Ghana. Ghana is a good test case because it is the only Low Income Country that is currently operating with an explicit inflation targeting framework in Sub-Saharan Africa. Moreover, the Bank of Ghana has been granted full independence since the bill was passed in December 2001 and the Monetary Policy Committee was established in September 2002.

Our objective is to develop a set of stylized empirical facts about Ghana in terms of the shocks that drive fluctuations. Our purpose is to investigate the type of shocks and model features that one would want to consider in building a structural DSGE model. The empirical facts here can then be used in such a model building exercise. This objective guides us in the type of shocks we consider. We are interested in the extent to which Ghana is exposed to international versus domestic shocks. This will motivate us to consider global counterparts to all of our shocks. We study a sequence of shocks that may be of importance to a country such as Ghana. First, we consider productivity shocks to measure the extent to which business cycles are driven by real factors. Second, we study credit market shocks to understand the importance of financial sector disruptions. Third, we consider commodity price shocks to measure the importance of such price changes of a dominant primary goods sector. We do not consider monetary policy shocks due to changes in monetary policy over the sample period. We leave this latter issue to a more structural investigation.

To identify shocks we use a standard macroeconomic tool–the Vector Autoregression (VAR), which we estimate with Bayesian methods. Identification of shocks is through a set of sign restrictions in the spirit of Uhlig (2005) for both the credit and productivity shocks. These use minimal but robust implications of structural models to impose restrictions on impulse response functions. For commodity price shocks we exploit the exogeneity of commodity prices for a small economy such as Ghana and use a recursive setup, with commodity prices ordered first. Global shocks are estimated using a similar set of restrictions on data constructed using the first principal component of G7 country level data.

In addition to studying the impact of shocks in Ghana we also study the impact of the same set of shocks in South Africa. The important question here is whether or not Ghana, which has a similar production structure and a monetary policy framework as South Africa, is fundamentally different. That is, in building a structural model for Ghana how much of our experience with models from more advanced and stable economies can we import?

This paper is related to the literature on the sources of macro-economic fluctuations in developing countries. One strand of this literature employs univariate methods to estimate cyclical variations in macroeconomic series (e.g. Agenor et al. (2000), Cashin (2004), du Plessis (2006) and Male (2011)). For instance, Agenor et al. (2000) employ de-trended methods to a set of macro-aggregates for 12 developing countries and find procyclical real wages, suggesting that productivity shocks play a dominant role in macroeconomic fluctuations of these economies. They also find countercyclical government expenditure, which implies that the government plays a stabilizing role in these economies. Finally, their analysis shows that the business cycle of advanced countries has a significantly positive impact on economic activity of developing countries. However, Male (2011) recently challenged this finding. She applies the classical cycle analysis, of Harding and Pagan (2002), to 32 developing countries and finds no clear patterns in the co-movement between business cycles of developing and advanced countries.

Another strand of the literature employs SVAR or theoretical models (e.g. see for instance, Broda (2004) Deaton and Miller (1996) Hoffmaister and Roldós (1997); Hoffmaister et al. (1998), Houssa (2008, 2009), Houssa et al. (2010), Houssa et al. (2013), Kose (2002), Kose and Riezman (2001), Mendoza (1995), Chia and Alba (2006)) and highlights the importance of two types of shocks: productivity shocks and terms of trade shocks.

This paper contributes to this literature by documenting the roles of credit supply and productivity shocks in developing countries, comparing domestic versus foreign nature of these shocks and their role in economies with a similar structure but at different stage of development. Especially, the study of macroeconomic impacts of credit supply shocks fills an important gap in the literature of Emerging Markets and LICs. To the best of our knowledge only Tamasi and Vilagi (2011) explicitly identify credit supply shocks for EMEs. They employ a BVAR model with sign restrictions and report that credit supply shocks account for a larger share of output fluctuations in Hungary. Other related studies have mainly used regression techniques to document a positive co-movement between credit and real activity (e.g. Akinboade and Makina (2010)). However, in such a framework is it difficult to distinguish correlation from causality. Moreover, such techniques do not systematically analyze the impacts of non-expected shocks. For research studying international transmission of credit shocks to EMEs; see Schnabl (2012) and Cetorelli and Goldberg (2011)).

The remainder of this paper is organized as follows. Section 2 presents a historical background on macroeconomic conditions in Ghana. Section 3 introduces the VAR model and discusses the structural identification strategy. Section 4 presents empirical results. Section 5 concludes.

1.2 Background on Macroeconomic Conditions in Ghana

Figure 1.1 and 1.2 present selected macroeconomic indicators for Ghana in $1980:1-2012:4$. Quarterly data on real activity is only available from 2006 for Ghana. As such, we estimate a measure of real activity growth for Ghana that covers a much longer time period. For this purpose we pool data from different frequencies (yearly, quarterly and monthly) and experienced with two approaches. We use the common component and the now-cast measures of real output (Giannone et al. (2008)). A plot of the series based on the former is on the left top panel of Figure 1.1 in the appendix.

Prior to 1983 Ghana suffered from macroeconomic instability which was most characterized by large internal and external deficits, limited foreign exchange reserves, high inflation, overvalued exchange rate, and negative economic growth (see Figures 1.1 and 1.2). In 1983 a Structural Adjustment Program was initiated under the denomination of Economic Recovery Program (ERP). ERP covers the period from April 1983 till March 1992. Its main components include a reduction of government deficit, tight (credit and) money growth, and a number of liberalization programs (in trade, prices, exchange rates). This break in policy leads to the start date of our sample.[1]

Monetary policy from 1983 switched from a direct control of credits and interest rates to a monetary targeting regime. The liberalization of interest rates charged by banks takes a gradual

[1] Actually we start in 1985 to account for this break in monetary policy in Ghana but also to account for the start of the globalization period in 1985.

route. Minimum and maximum deposit (except saving) rates were removed in 1987; minimum lending rates for commercial banks were abolished in 1988 and commercial banks were given the right to fix their own rates in 1989 (Sowa and Acquaye (1999)).

In the framework of the new monetary policy three targets were set: *i)* the reserve money as the operating target; *ii)* the money supply as the intermediate target; *iii)* and the general price level as the ultimate target (Abradu-Otoo et al. (2003)). The implementation of monetary policies with these targets was undertaken within the Financial Programming Framework. Explicitly the implementation of monetary policy involved four phases. In the first step the money supply target is determined, with the quantitative money equation, given the target for the price level and the level of activity. In the second step, the money base target is determined given the money multiplier. Third, the level of net domestic asset is determined using the balance sheet identity of BOG given targets of reserve money and the net foreign asset. Fourth, an open market operation is used to achieved the level of NDA. These procedures were in place till 2001 where the Bank of Ghana started the transition to inflation targeting regime, which was formally adopted in 2007. These changes in policy throughout the sample motivate us to not consider VAR based monetary policy shocks. We conjecture that a structural approach will be more appealing for these shocks.

Prior to ERP Ghana operated a fix exchange rate regime but adjustments of the cedi were frequent (1967, 1971, 1972, 1976). In 1983 a liberalization of the exchange rate begun with a gradual approach in six phases where full liberalization was achieved in 1990 when for the first time the exchange rate was set in the inter-bank market (Sowa and Acquaye (1999)). Since then the currency is in principle allowed to fluctuate. As most small open economies, however, authorities intervened in the foreign exchange market. With flexible exchange rate global shocks are likely to impact Ghana, in part motivating our consideration of augmenting our VAR with global factors.

Ghana exports three main commodities: cocoa and gold are traditional commodities and from 2011 Ghana started exporting crude oil. Our commodity price shocks will focus on the former two as they are produced for the entire sample.

1.3 Methodology

1.3.1 Bayesian Vector Auto-Regressive (BVAR) Model

Consider the following Vector Auto-Regressive (VAR) model,

$$Y_t = A_0 + A_1 Y_{t-1} + ... + A_P Y_{t-P} + \mu_t, \tag{1.3.1}$$

where Y_t is a $n \times 1$ vector of home and foreign real, nominal and financial indicators; the A_i are $n \times n$ auto-regressive coefficients, A_0 contains the constant terms, and μ_t is a $n \times 1$ vector of Gaussian white noise with covariance matrix $\Psi = E(\mu_t \mu_t')$. The G7-countries represent our foreign economy whereas for the home economy we focus on either Ghana or South Africa.

The series included in Y_t depend on the type of structural shocks being estimated. We identify two categories of shocks: credit and productivity shocks, on the one hand; commodity price shocks on the other hand. For credit and productivity we consider global as well as domestic versions of the shocks.

1.3.2 Credit and Productivity Shocks

The productivity shocks we consider are interpreted as exogenous shocks to total factor productivity. In the context of a DSGE model this would be the standard Solow residual. The credit shocks we study are exogenous shocks to the supply of credit. To study credit and productivity shocks we estimate a VAR model with 16 variables. In particular, Y_t includes six indicators of the foreign economy: G7-real GDP; G7-inflation; G7-real credit; G7-short-term interest rates; US-credit spread; and US-default rates. The four G7-factors are estimated by extracting the first principal component from the series of G7 countries. For the remaining two indicators we use US series because of data limitation.

The remaining 10 series of Y_t relate to the home economy. We include six indicators of the domestic economy analogous to those of G7-countries. Moreover, the home- block contains four indicators allowing to capture the transmission of foreign shocks to the domestic economy: exports, imports, primary commodity prices, and the real exchange rate. The VAR is setup so that global shocks impact Ghana (or South Africa), but domestic shocks have no impact on global aggregates.

We use quarterly data from Ghana, South Africa and G7-countries in $1985:1-2010:3$.[2] Where appropriate we transform the series in year to year growth rates. Table 1.1 reports detailed information on the dataset and the transformation applied to each series. For the South African economy we measure the credit spread by the difference between the yield on Eskom and the US baa bond. As a proxy for the default rate we make use of data on the number of insolvencies on loans.

We use the US corporate credit spreads (baa-aaa) as the measure of the price of risky credit for G7-countries. To measure default on credit for G7-countries we also use a proxy for the US economy. In particular, we use the distance to default measure proposed by Gilchrist et al. (2009). We take the inverse of this indicator and transform it to a year to year growth rate.

[2] We start in 1985 to account for the break in monetary policy in Ghana that occurred in 1983 but also to account for the start of the globalization period in 1985. We end the SVAR analysis sample in 2010:3 for data limitation on the coverage of the US default rate.

We estimate Eq. (1.3.1) using Bayesian methods with 3 lags. In all BVAR models we employ a combination of two types of priors: *i)* a Normal-inverted Wishart prior; and *ii)* a Minnesota type prior that assigns low weights on off-diagonal AR coefficients and specifically zeros weights on coefficients related to the home economy's indicators in the block defined by (primary) commodity prices and G7-factors.[3] The later restrictions are consistent with the Small Open Economy (SOE) assumption for Ghana and South Africa.

For the structural identification, we employ a set of zero and sign restrictions. These restrictions are implemented with the penalty function approach proposed by Mountford and Uhlig (2009) and Uhlig (2005). We explicitly modify the objective function in order to also allow for zero restrictions. The results reported in the paper are based on the following sequential ordering: G7-credit shocks, G7-productivity shocks, domestic (SA or GHA)-credit shocks and domestic (SA or GHA)-productivity shocks. However, using a different ordering does not change the main results of the paper. Table 1.2 reports the identification restrictions for the four shocks. In all cases, the restrictions assume negative shocks and are imposed over the first four quarters.

Zero restrictions allow to disentangle South African shocks from global shocks. In particular, we assume that G7 countries do not respond to shocks originating from South Africa. On the other hand, sign restrictions help to distinguish exogenous credit supply shocks from the endogenous response of credit to macroeconomic conditions. The identification of credit supply shocks is based on the recent literature (e.g. Helbling et al. (2011) and Meeks (2012)). We assume that an adverse credit supply shock is characterized by an increase in the credit spread and a decrease in real credit. In addition, we require that default rates on corporate bonds do not increase. This additional restriction helps to isolate the endogenous response of credit to fundamental macroeconomic shocks (see Meeks (2012)). Note that we leave unrestricted the IRFs of other series in Y_t including Real GDP, inflation, the monetary policy rate etc ...

For adverse productivity, we impose that real credit does not increase. Moreover, we require for these shocks that default rates do not decrease. Again, this later restriction is employed to discriminate credit supply shocks from endogenous responses of credit to fundamental (productivity and demand) macroeconomic shocks. We identify negative productivity shocks as decreases in output that increase inflation, as implied by a New Keynesian DSGE model. For advanced economies one can also include productivity itself in the VAR. Helbling et al. (2011) do so and find that the additional data does not affect the estimated responses. As we do not have productivity data for Ghana we do not include any measure of productivity in the VAR.

[3]The results reported in the paper are based on 250 draws. Using a larger number of draws leaves qualitatively the results unchanged.

1.3.3 Commodity Price shocks

To identify commodity price shocks we consider a VAR model with six variables: commodity price; CPI, GDP, Credit; short-term interest rate and the real effective exchange rate. We follow the standard approach of the literature and impose the recursive identification scheme on these shocks, with commodity prices ordered first (e.g. Broda (2004) and Mendoza (1995)).

Analysis focuses on gold price allowing to understand how Ghana and South Africa respond to similar commodity price shocks. We deflate the nominal commodity price series by the US producer price index (PPI). Moreover, we estimate the economic impact of an increase in commodity prices over three sample periods: i) the full sample $(1985:1-2010:3)$; i) before the introduction of the inflation targeting framework (IT); and iii) after the introduction of the inflation targeting framework. For South Africa, the before and after IT periods are: $1985:1-1999:4$ and $2001-2010:3$. For Ghana these are $1985:1-2001:4$ and $2002-2010:3$. In each case we fix the lag length to 3.

1.4 Empirical Results

1.4.1 *Global Shocks and Fluctuations in Ghana and South Africa*

In this section we study the impact of global productivity and credit shocks on Ghana and South Africa. Figures 3 and 4 report responses to G7 shocks. A full analysis of G7 responses to these shocks can be found in Helbling et al. (2011). The results can be briefly summarized as credit supply shocks have negative but relatively modest impacts on global output, while productivity shocks have sharp and persistent impacts on global output.

The IRFs to the global credit supply shocks in Figure 3 show that there is a significant impact on output in South Africa, but not in Ghana. Looking at the responses to other variables we see that the credit shock has a modest reduction in credit in both countries. This is suggestive that while South Africa is financially integrated such that global credit conditions affect the domestic economy, Ghana is not. In other words, global credit supply is not important for financing the production of Ghanian GDP. The difference in impact of the shock can also be seen on commodity prices. The credit supply shock lowers commodity prices in South Africa, while raising them in Ghana. Understanding the differences in the financing of the production of the two types of commodities will be important for understanding the role of credit markets in these primary goods producing countries.

In Figure 4 we plot the responses to G7 productivity shocks. For both Ghana and South Africa we see similar shapes and magnitudes for the response. Given that Crucini et al. (2011) find that the global business cycle is primarily driven by productivity shocks this result is not surprising. From a modelling perspective it suggests that standard formulations for global productivity shocks are appropriate for Ghana. The response of inflation is also in line with the prediction of a New Keynesian model, where drops in productivity are inflationary. Note that while global inflation is constrained to rise after the contractionary shock, there are no restrictions on Ghanian inflation. In terms of commodity prices we see that prices fall in both South Africa and Ghana, though the impact is not significant in Ghana. Again, highlighting that Ghana is not as integrated with the world as is South Africa.

Finally, we see that the world gold price increases following adverse productivity and credit shocks, though the impact is modest.

1.4.2 *Domestic Shocks and Fluctuations in Ghana and South Africa*

Domestic credit supply shocks are shown in Figure 5. They generate similar inflationary pressures in South Africa and Ghana as did the global shocks. They have a quantitatively larger impact in Ghana. The inflation pressures of credit supply shocks are in line with the models presented in Atta-Mensah and Dib (2008) and Gerali et al. (2010). The effects of the shock leads to an increase in interest rates in Ghana and South Africa, though the impact is only significant for a short period of time. This is suggestive that inflation is more important for both countries than the small output losses caused by financial market disruptions. The similarities in responses suggest that monetary policy rules in South Africa can be exploited in building a model for Ghana.

Domestic productivity shocks, shown in Figure 6, have a significant impact on Ghana, and a more muted impact on South Africa. By construction these shocks lower output and raise inflation in both countries. The interesting result is the difference on the other variables in the VAR. In response to the shock short term interest rates rise in Ghana and fall in South Africa. These responses cause a real exchange rate appreciation in Ghana, lowering exports and raising imports. In South Africa real exchange rates do not move, while exports fall and imports rise. This points to monetary policy focusing on inflation pressures more than output drops in Ghana then in South Africa. A interesting question is if a policy rule in the context of a DSGE model can justify such a strong response. If not, a lack of credibility for the central bank may be leading to aggressive responses of monetary policy to inflation to build credibility.

1.4.3 *Commodity Price Shocks*

Figure 7 displays the dynamic responses of various indicators to gold price shocks in both countries. Considering first the full sample results shows that output decreases on impact in South Africa but latter increases significantly and turns to positive values during several quarters. On the contrary, output increases significantly on impact following an increase in gold prices. A similar result can be observed before IT but during the IT period the impact response is negative in Ghana as well. One explanation of the different impact period responses could capture the earlier result that G7 adverse shocks cause an increase in gold price but also a much stronger recession in South Africa.

Comparing the results across sub-periods shows that for South Africa output response to gold shocks have become less persistent during the IT period. This result may have to due to do with the different responses of inflation and the policy rate to gold price shocks across the two periods. In particular, before the IT inflation increases on impact but decreases significantly following the shocks. During IT, on the other hand, inflation show positive responses. As such, the central bank raises the policy rate to respond to inflationary pressure during the IT period and this policy action also helps in containing the output boom. The response of the bank of Ghana during IT follows a similar line in responding to inflation that decreases on impact and increases later. As such, the policy rate also decreases first and later increases. The BOG before IT is more difficult to explain as inflation and output increase on impact but the policy rate is reduced.

1.4.4 *Variance Decomposition Analysis*

Tables 1.3 and 1.4 report the median percentage variance shares of selected series that are due to each of the shocks. Considering the 3-year horizon for credit and productivity shocks shows that the global shocks are more important in both countries although these shocks have a larger impact in South Africa than in Ghana (Table 1.3). Moreover, these two global shocks explain about the same share of variation of the macroeconomic aggregates in both countries. For instance, each of these global shock explains about 8 and 11% of output variation in Ghana and South Africa, respectively. Helbling et al. (2011) report a similar finding indicating that the global credit and productivity shocks explain each about 12% of output fluctuation in G7-countries.

In the short-term domestic credit and productivity shocks dominate their global counterparts for inflation and credit. Especially, domestic productivity shocks are the main drivers of output and inflation fluctuations in the short run. For real credit domestic credit shocks account for a large portion of the volatility, with productivity shocks contributing as well. For the short-term interest rates and the real effective exchange rates the global credit and productivity shocks are still important, explaining 10 percent of the volatility. This result may reflect the use of those two instruments for stabilizing external shocks.

Finally, commodity price shocks are also more important for South Africa than for Ghana (Table 1.4). Moreover, the share of variance due to this shock is in general a bit larger than the one of productivity or credit shocks for both countries. In addition, there has been an increase of the role of commodity price shocks in macroeconomic fluctuation in Ghana and South Africa in recent years. In the inflation targeting regime commodity price shocks account for 20-25 percent of the volatility of all variables in the VAR. This reflects the dependence on the commodity sector in these economies.

Taken together our five shocks (using the IT period of commodity price shocks) account for half the fluctuations in our main macroeconomic variables. A full accounting of the macroeconomic volatility in Ghana will likely require both fiscal and monetary policy shocks in addition to our shocks. In this study we have chosen to focus on exogenous shocks rather than policy shocks. Limits on data on fiscal policy make studying the impact of Fiscal shocks in a VAR framework difficult. As noted earlier, the frequent changes in monetary policy structure do not lend themselves well to a VAR analysis. The former would be best studied using a narrative approach, while the latter with a regime switching structural model.

1.5 Conclusion

In this paper, we analyze the role of domestic and global shocks in explaining business cycles in Ghana and South Africa. For this purpose, we use a medium-scale Bayesian Vector Auto-Regressive (BVAR) model that captures the dynamics macroeconomic indicators in G7-countries and in each of these two countries.

We find that global productivity and credit shocks have a greater impact on South Africa than in Ghana. The fact that global credit market shocks do not affect Ghana while productivity shocks do is suggestive that Ghana's integration with the world is more through trade channels, and less through financial channels. Domestic versions of both shocks highlight a key difference between South Africa and Ghana in that monetary policy in Ghana has responded more strongly to inflation than drops in output. Finally, we find that commodity shocks are an important driver in business cycles in both countries. This result highlights the importance of a primary goods sector in developing a model for business cycle stabilization in Ghana. In contrast, shocks traditionally emphasized in advanced economies (productivity, credit) play a more muted role.

Figure 1.1: Selected Macroeconomic indicators for Ghana (YoY percent)

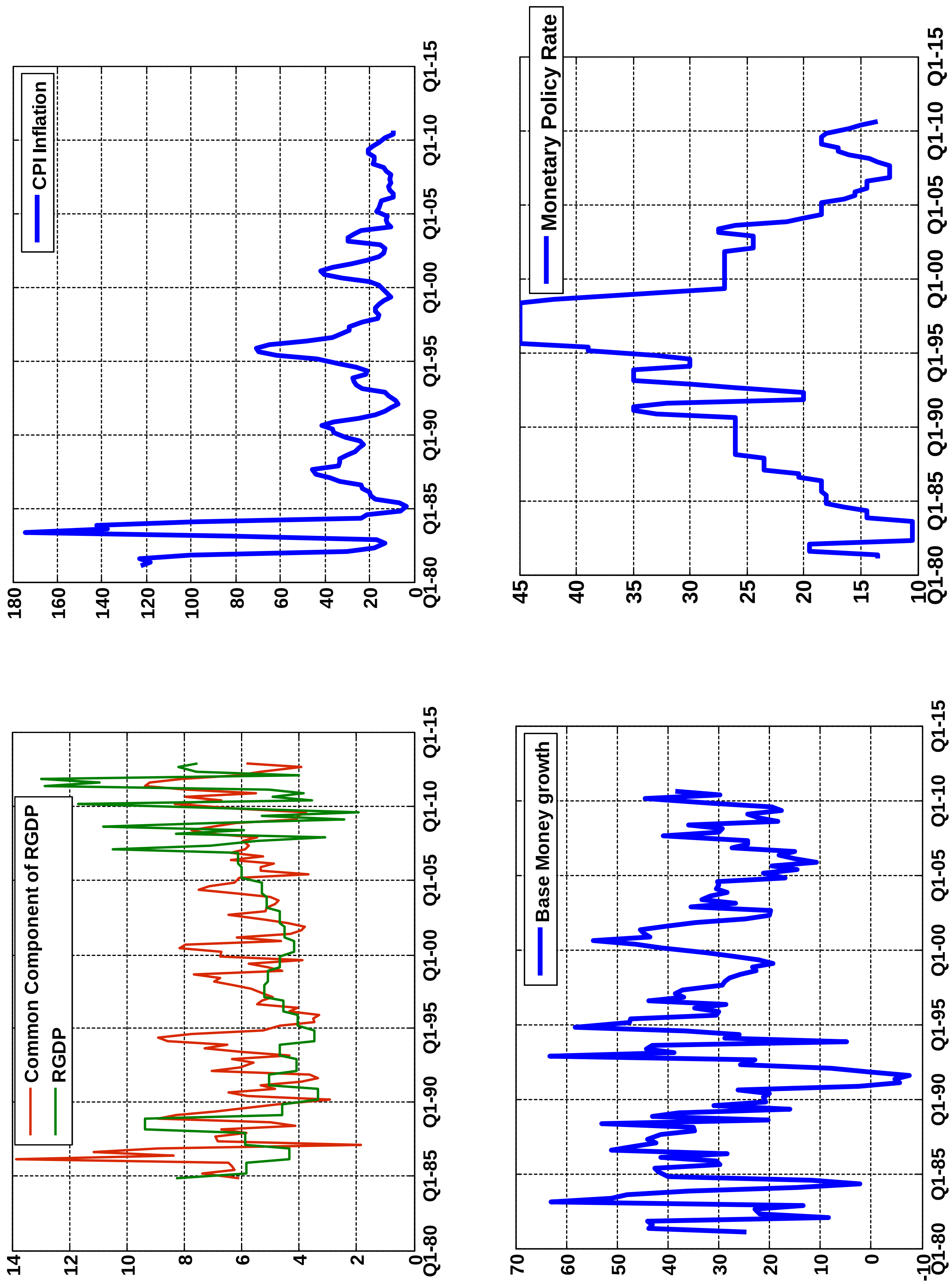


Figure 1.2: Exchange Rates and International Reserves (YoY percent)

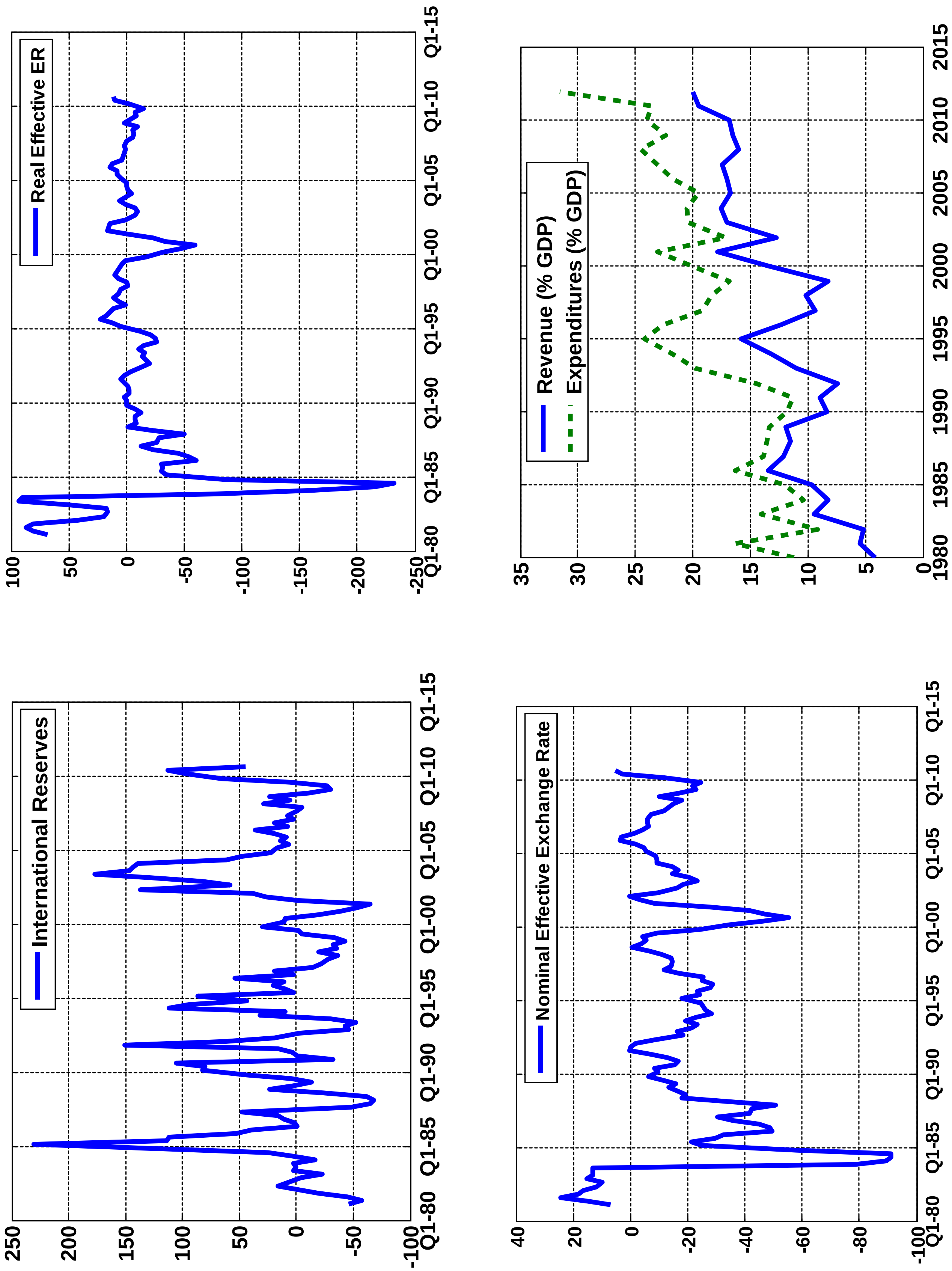


Figure 1.3: G7 Credit Shocks

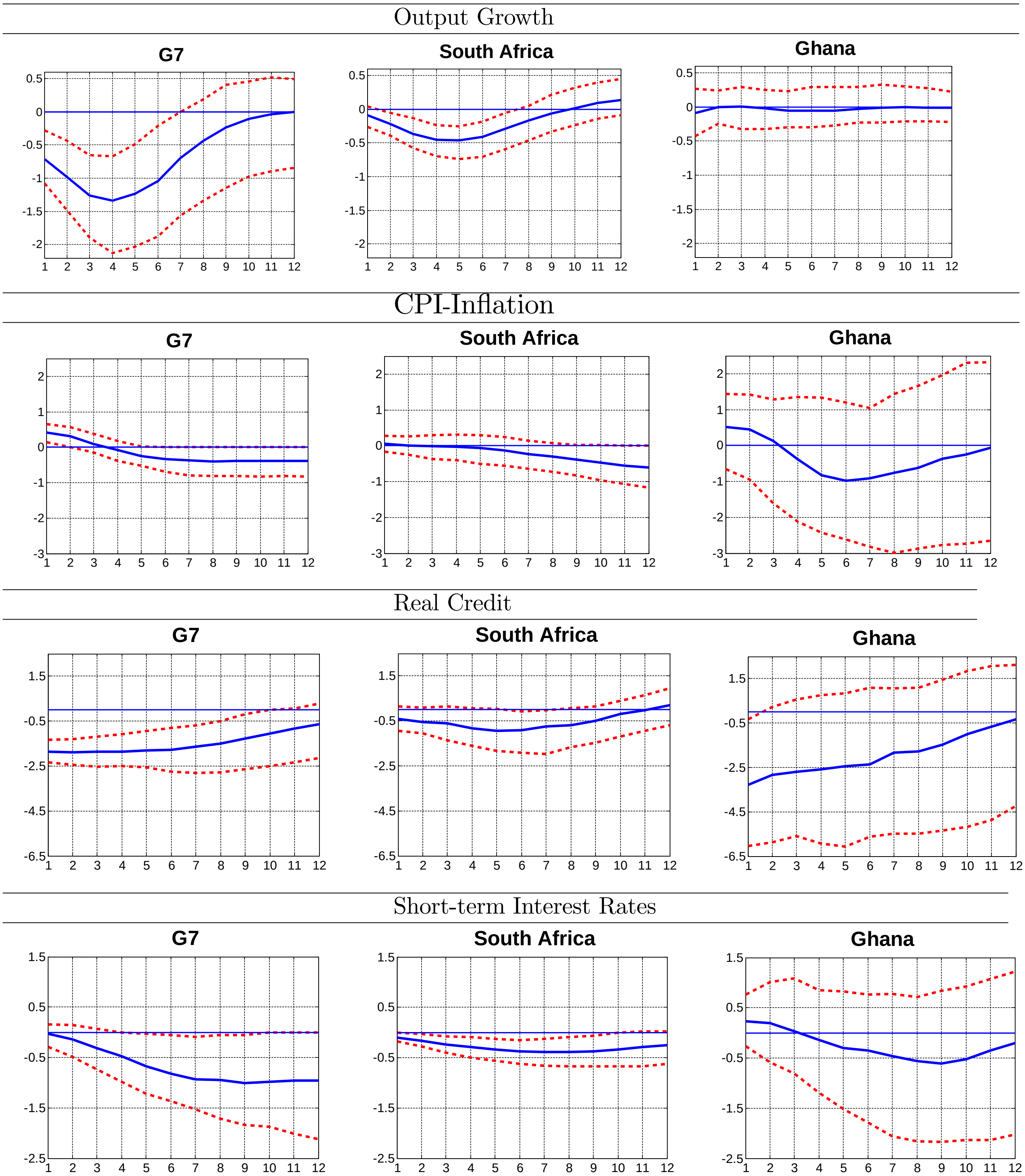
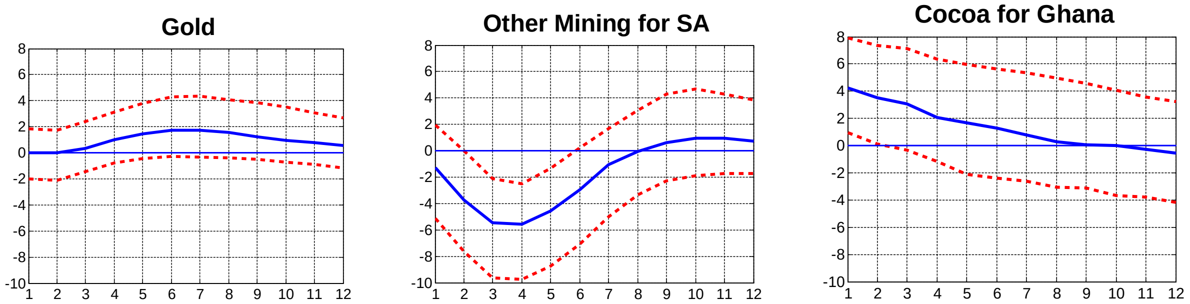
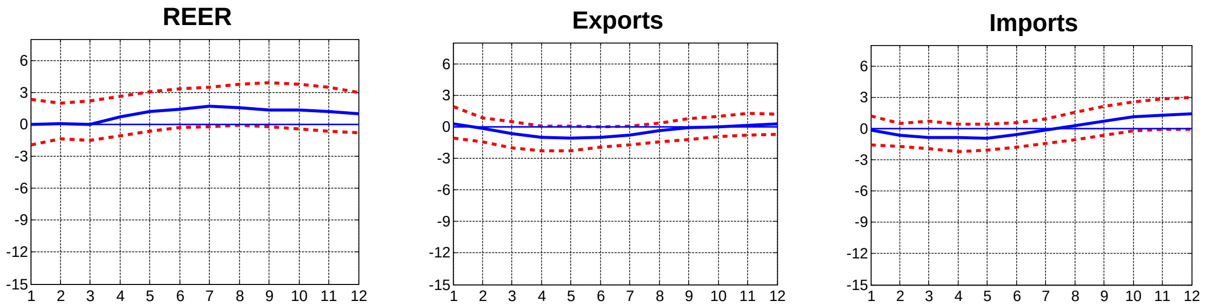


Figure 3: G7 Credit Shocks (Continued)

Commodity Prices



REER and Trade in South Africa



REER and Trade in Ghana

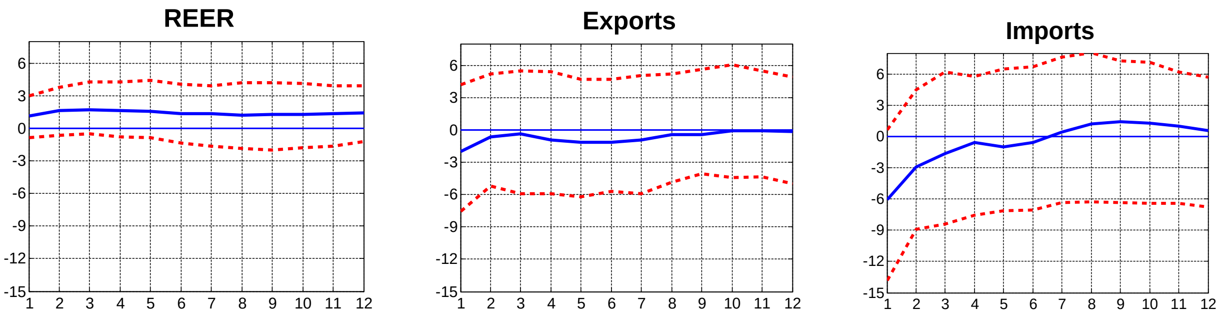


Figure 1.4: G7 Productivity Shocks

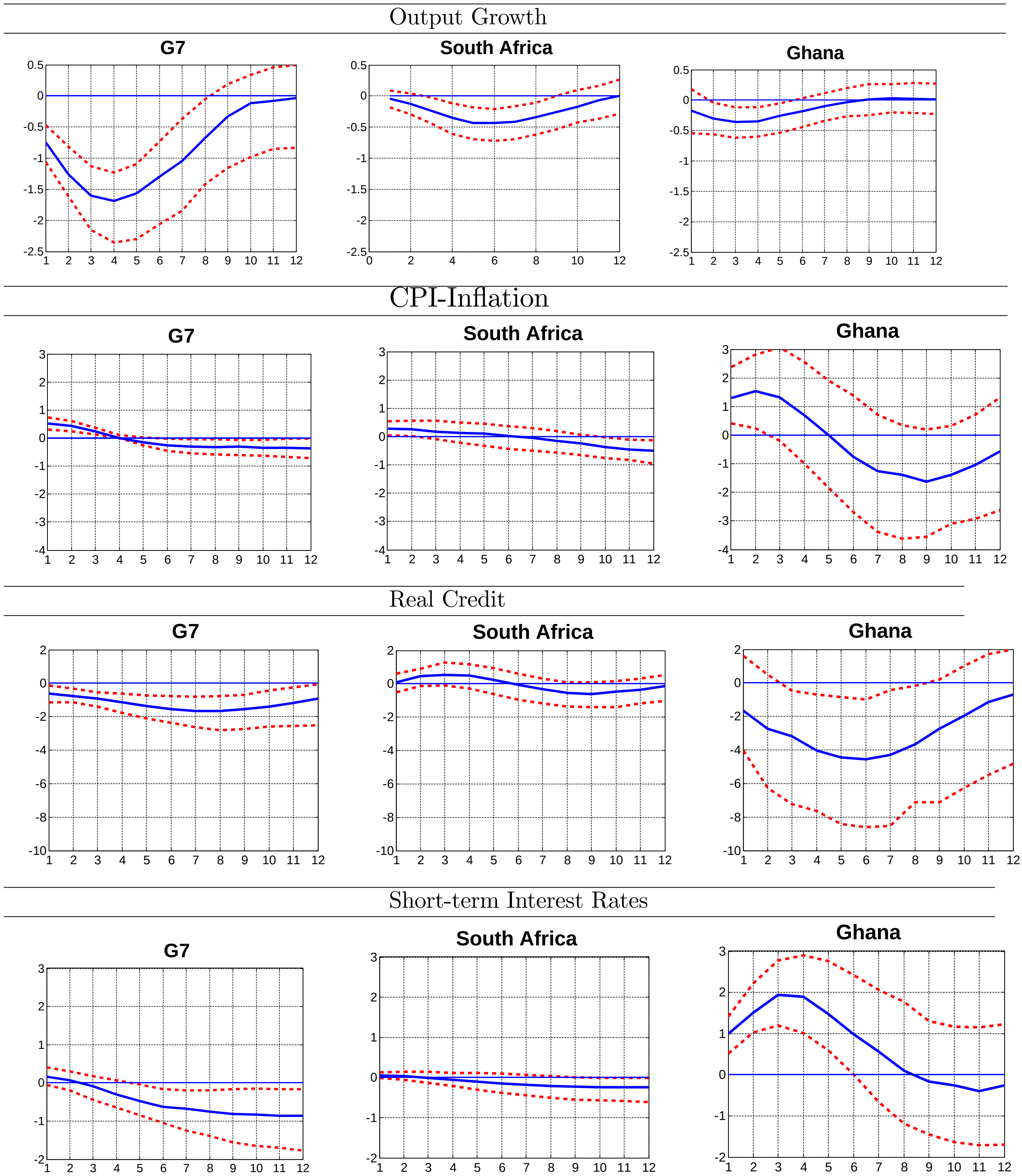
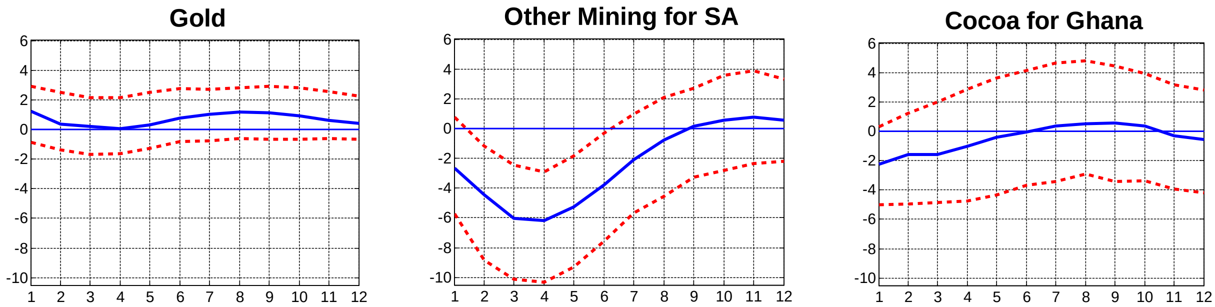
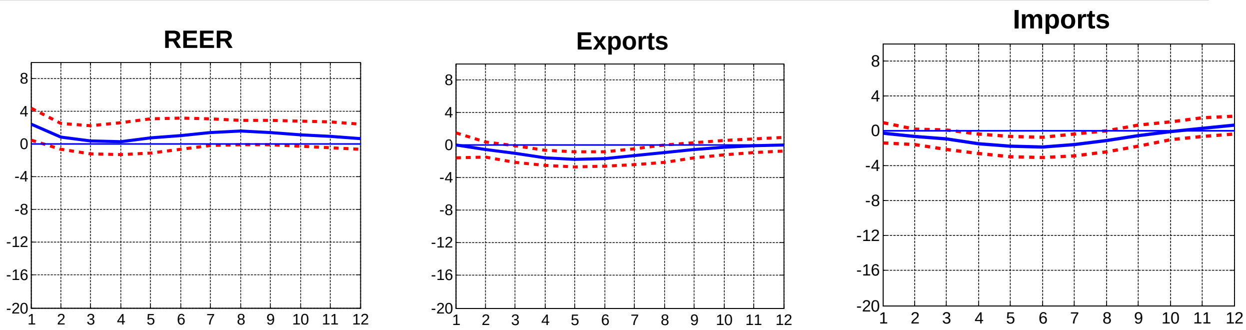


Figure 4: G7 Productivity (Continued)

Commodity Prices



REER and Trade in South Africa



REER and Trade in Ghana

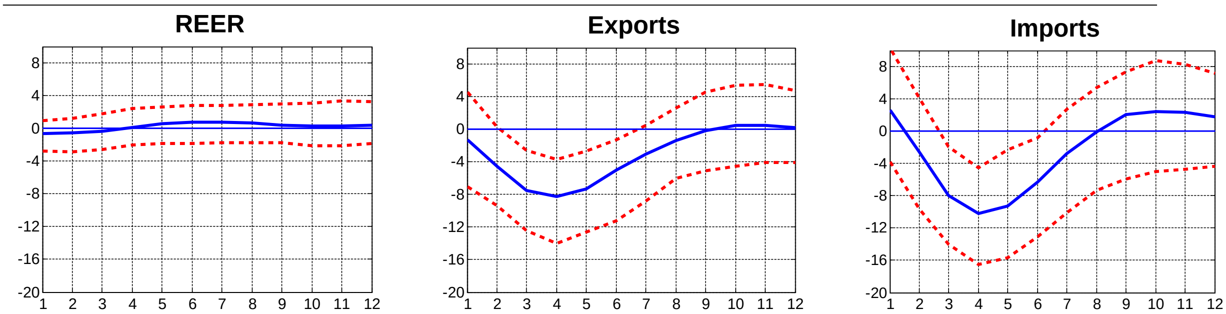
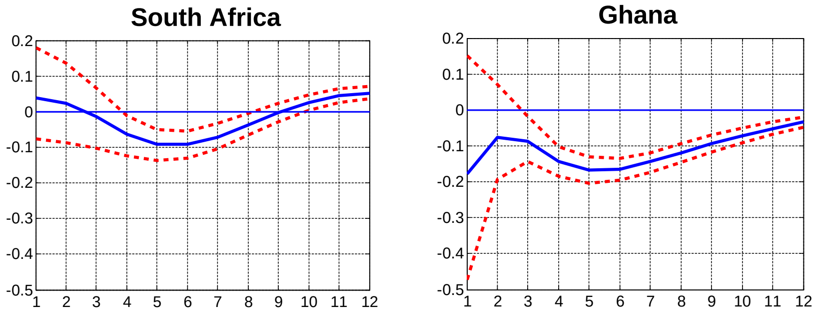
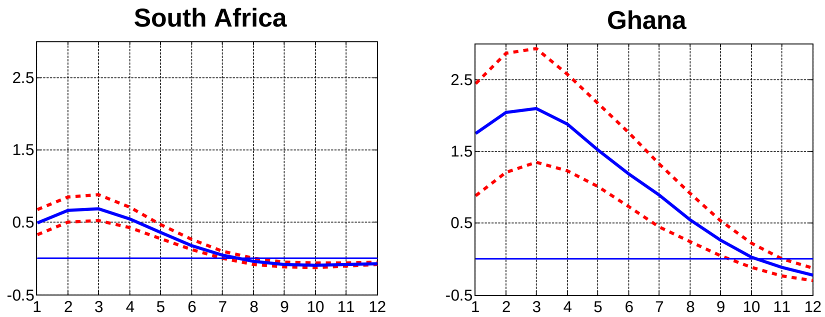


Figure 1.5: Domestic Credit Shocks

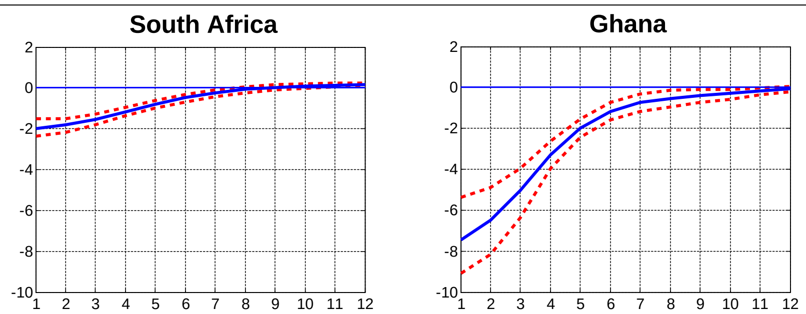
Output Growth



CPI-Inflation



Real Credit



Short-term Interest Rates

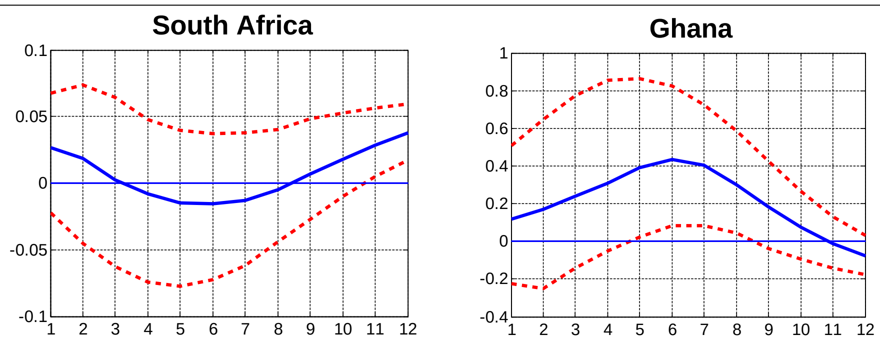
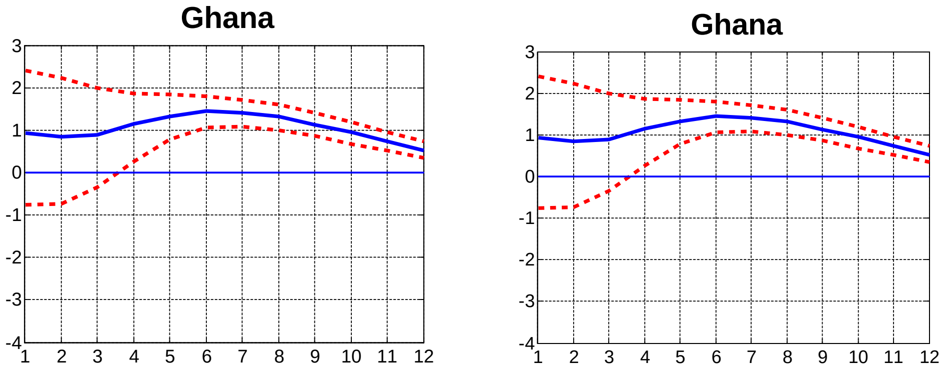
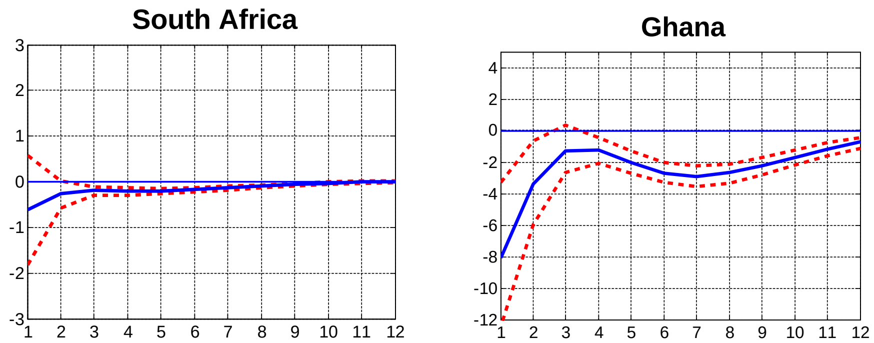


Figure 5: Domestic Credit Shocks (Continued)

Real Effective Exchange Rates



Exports



Imports

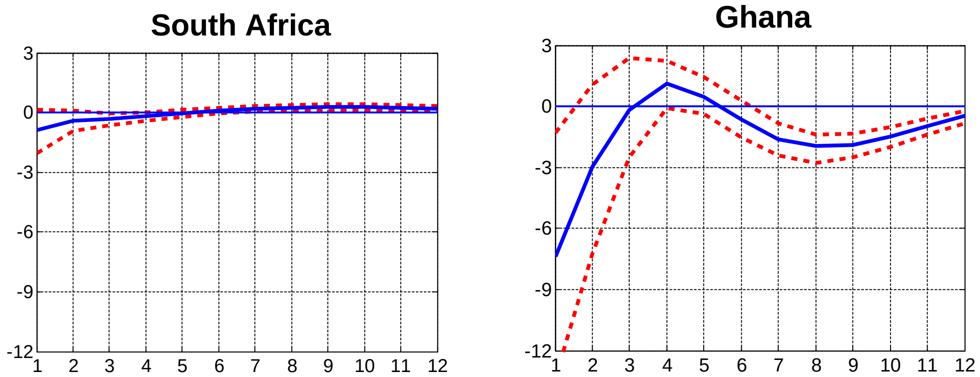


Figure 1.6: Domestic Productivity Shocks

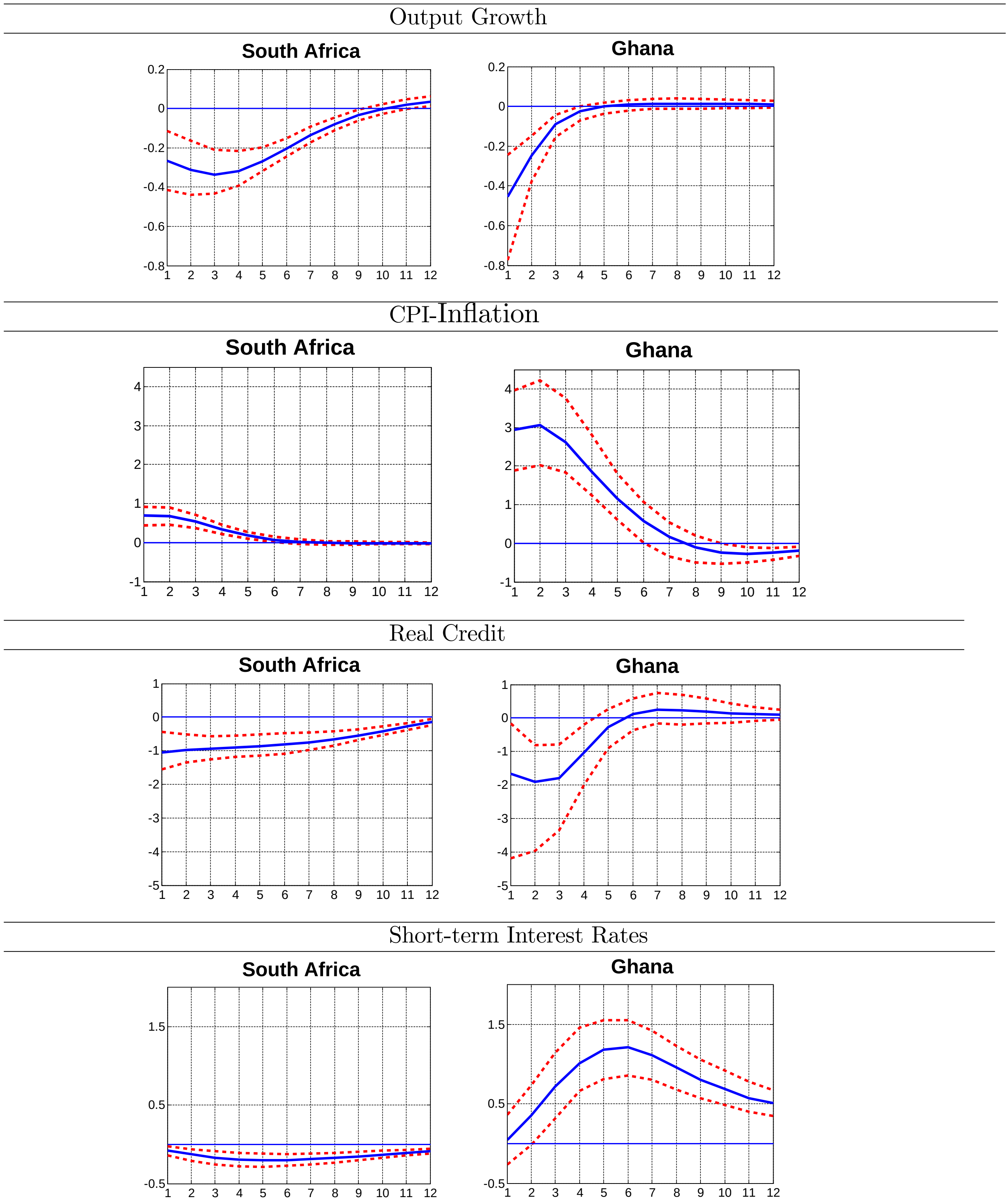
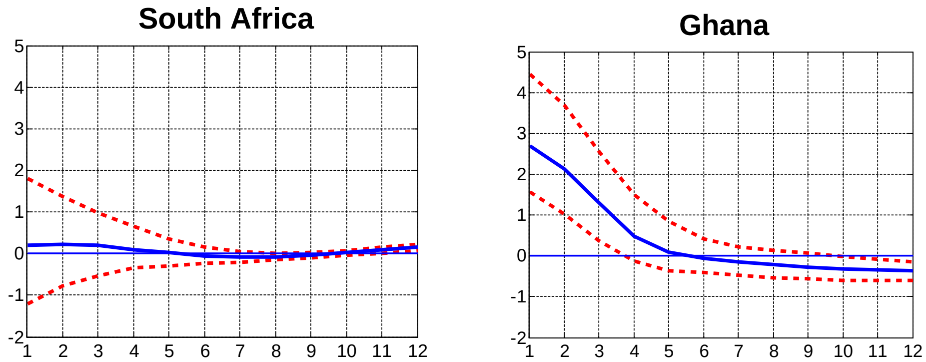
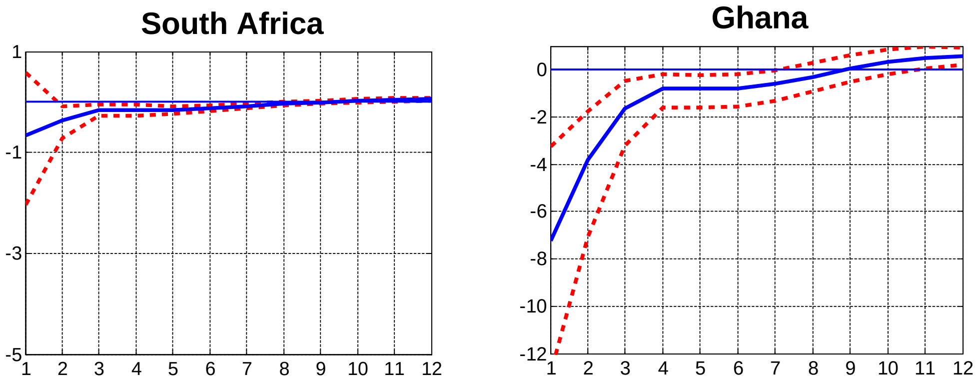


Figure 6: Domestic productivity Shocks (Continued)

Real Effective Exchange Rates



Exports



Imports

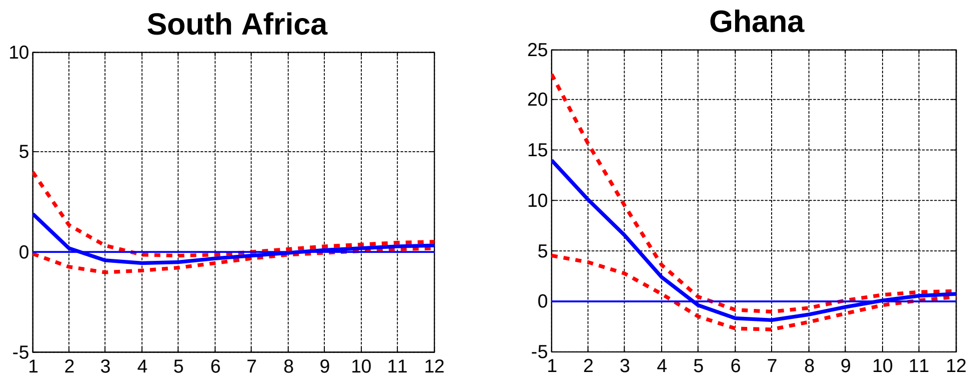
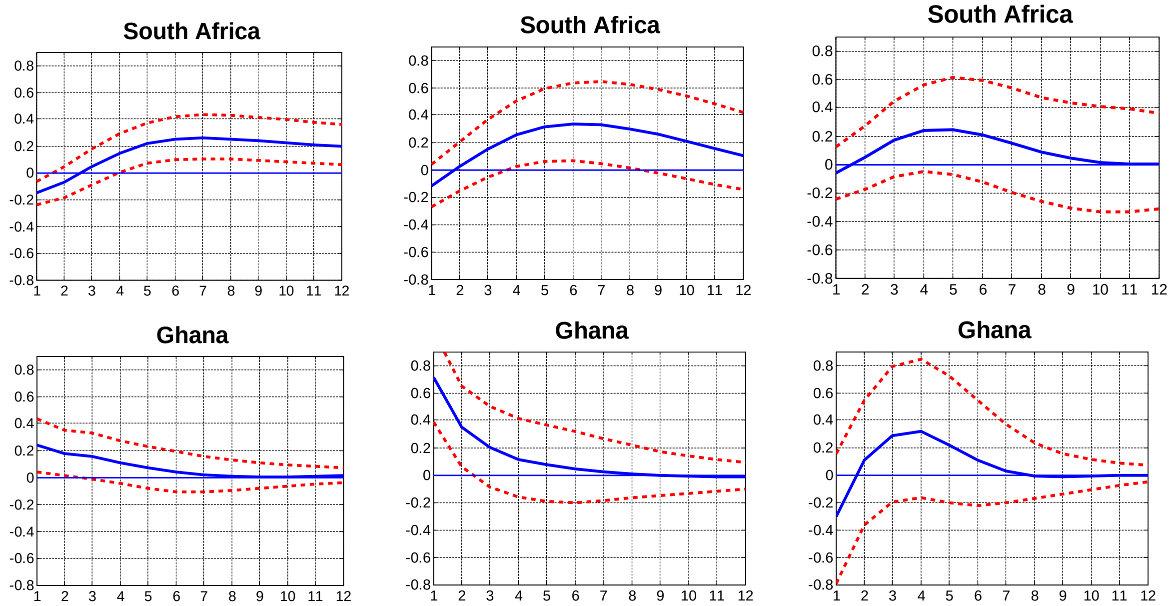


Figure 1.7: Commodity Price Shocks

Full Sample	Before IT	During IT

Output Growth



CPI-Inflation

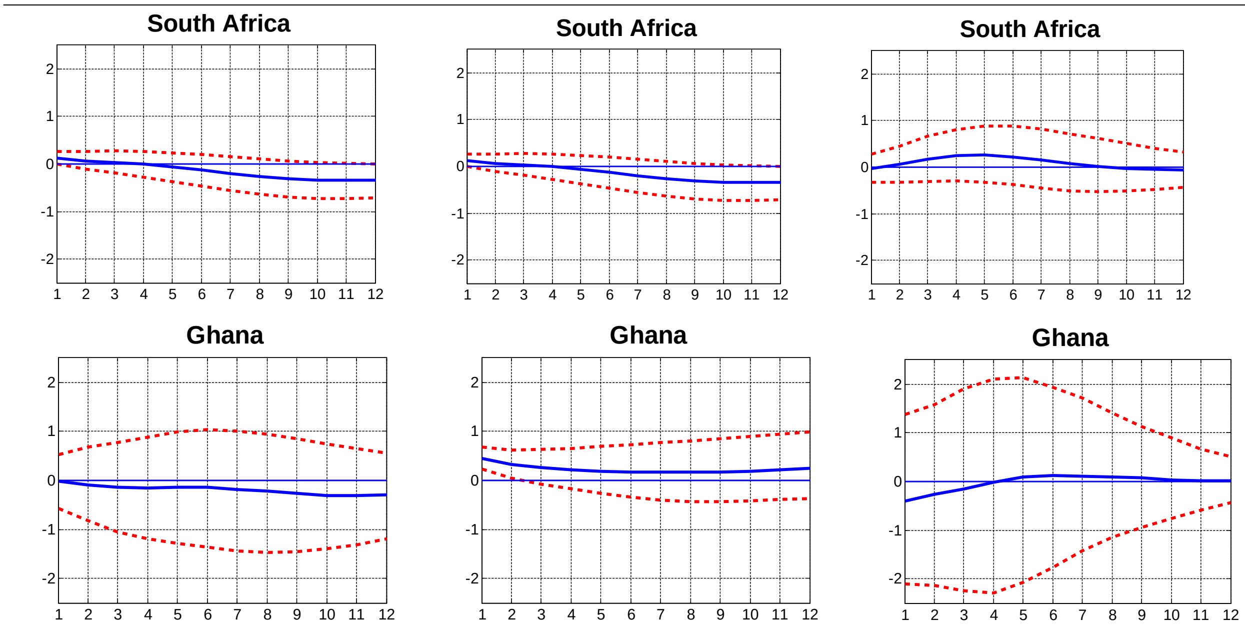
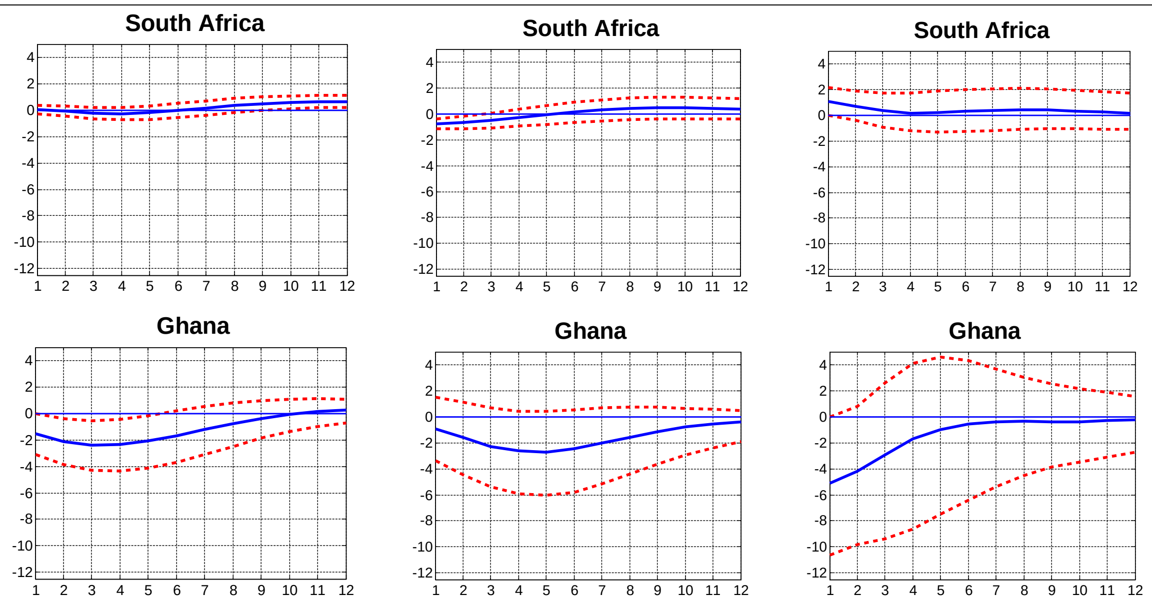


Figure 7: Commodity Price Shocks (Continiued)

Full Sample	Before IT	During IT

Real Credit



Short-term Interest Rates

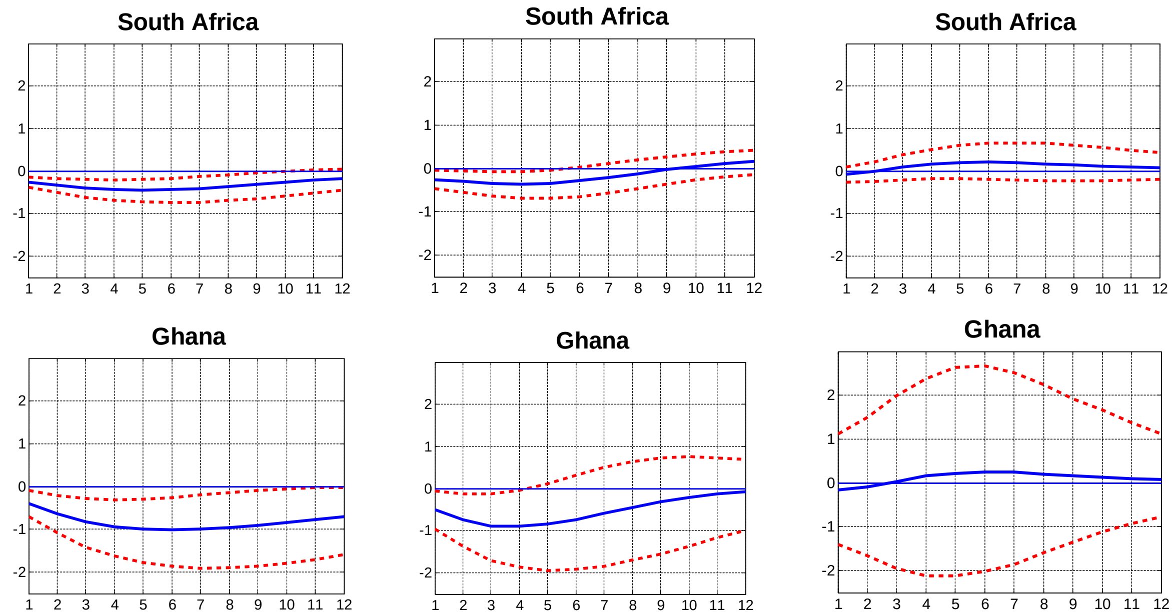


Table 1.1: Data

Part A

	Output	Real Credit	Short-run interest rates	CPI
trans.	**year to year**	**year to year**	**level**	**year to year**
Canada	OECD, Gross domestic product, volume, market prices	IFS, CLAIMS ON PRIVATE SECTOR	IFS, TREASURY BILL RATE	
France	OECD, Gross domestic product, volume, market prices	IFS, CREDIT TO PRIVATE SECTOR	IFS, TREASURY BILLS:3 MONTHS	IFS, CPI: 108 CITIES
Germany	OECD, Gross domestic product, volume, market prices	IFS, CLAIMS ON OTH RESSID SECTOR	IFS, TREASURY BILL RATE	GDS, Consumer price index
Italy	OECD, Gross domestic product, volume, market prices	IFS, CLAIMS ON OTHER RESIDENT SECTORS	IFS, TREASURY BILL RATE	IFS, CPI:ALL ITALY
Japan	OECD, Gross domestic product, volume, market prices	IFS, CLAIMS ON PRIVATE SECTOR	IFS, FINANCING BILL RATE	IFS, CPI:ALL JAPAN-485 ITEMS
UK	OECD, Gross domestic product, volume, market prices	IFS, CLAIMS ON PRIVATE SECTOR	IFS, TREASURY BILL RATE	IFS, CPI: ALL ITEMS
USA	OECD, Gross domestic product, volume, market prices	IFS, CLAIMS ON PRIVATE SECTOR	IFS, TREASURY BILL RATE	IFS, CPI All ITEMS CITY AVERAGE
G7	First principal component	First principal component	First principal component	First principal component
South Africa	SARB, Gross Domestic Product (SAAR, Mil.2005.Rand)	SARB, Credit extension: Domestic Private Sect Claims (SA, EOP, Mil.Rand)	Treasury Bill Tender Rate, 91-Days	CPI: All Items
Ghana	GSS, Gross Domestic Product (SA, Mil.2006.Cedis) Backcast data from 1990-2005	IFS, Claims on Private Sector	Treasury Bills Discounted	IFS, CPI National

Part B

	credit spreads	default	Real Effective exchange rate	Commodity prices	Export of goods	Import of goods
	level	**year to year**	**year to year**	**year to year**	**year to year**	**year to year**
USA	Macrobond, baa-aaa on US corporate bond yields	Gilchrist et al. (2009), distance to default transformed to inverse distance				
South Africa	SARB, Spreads between Eskom bond yield and US-baa bond yield	South Africa Statistics, Insolvencies (Number)	IFS, Real Effective Exchange Rate of the Rand	IFS, gold other mining: aluminium, coal, platinum	OECD MEI, Exports of Goods And Services , SA, Index	OECD MEI, Import , Goods and Services Volume Indices
Ghana	SA credit spreads	SA default rates	IFS, Real Effective Exchange Rate Based on Relative CPI	IFS, cocoa, gold	IMF DOTS Exports of Goods And Services	IMF DOTS Imports of Goods and Services

Table 1.2: Indentification Restrictions

N°	Indicators	G7-aggregate		Domestic (SA or GHA)	
		Credit	Productivity	Credit	Productivity
1	G7-Real GDP		−	0	0
2	G7-Inflation		+	0	0
3	G7-Real Credit	−	−	0	0
4	G7-Tbil			0	0
5	US-Credit Spread	+	+	0	0
6	US-Default	−	+	0	0
7	(SA or GHA)-Real GDP				−
8	(SA or GHA)-Inflation				+
9	(SA or GHA)-Real Credit			−	−
10	(SA or GHA)-Tbil				
11	SA-Credit Spread			+	+
12	SA-Default			−	+
13	(SA or GHA)-Commodity Price			0	0
14	REER of the rand or the GHS				
15	(SA or GHA)-Export				
16	(SA or GHA)-Import				

Table 1.3: Variance Decomposition for Credit and Productivity Shocks

		G7-Credit	**G7-Productivity**	**Dom.-Credit**	**Dom.-Productivity**
	Horizons		Output Growth		
	1	3.08	2.25	0.68	8.35
	4	6.65	6.46	1.32	5.73
South Africa	8	9.38	10.40	1.47	3.97
	12	10.10	11.24	1.26	3.07
	1	2.86	2.78	1.24	4.41
Ghana	4	5.43	6.16	1.13	3.51
	8	6.84	7.32	1.50	3.10
	12	7.81	8.04	1.41	2.98
			CPI-Inflation		
	1	3.02	3.20	11.50	18.37
	4	4.06	4.02	9.36	14.46
South Africa	8	6.24	6.08	5.96	8.76
	12	8.62	8.08	3.86	5.58
	1	3.13	3.28	7.21	19.70
Ghana	4	4.07	4.56	6.95	16.41
	8	6.92	6.83	4.83	9.50
	12	8.48	8.00	3.72	7.58
			Short-term Interest Rates		
	1	3.82	4.03	1.21	1.46
	4	5.54	5.74	1.54	2.03
South Africa	8	8.59	8.80	1.41	1.81
	12	9.79	10.28	1.15	1.38
	1	4.05	4.81	1.46	0.84
Ghana	4	6.45	8.61	2.51	2.24
	8	8.30	8.85	3.40	2.76
	12	8.99	9.55	3.18	2.25
			Real Credit		
	1	2.39	2.27	16.38	6.71
	4	5.09	5.65	12.72	5.53
South Africa	8	7.41	8.09	9.32	4.44
	12	8.74	9.41	7.66	3.96
	1	3.34	2.28	12.25	1.74
Ghana	4	5.78	4.53	9.01	2.57
	8	8.29	7.79	6.41	2.47
	12	9.27	8.78	5.37	2.12
			Real Effective Exchange Rates		
	1	5.11	5.97	2.25	2.25
	4	6.38	6.32	2.34	2.32
South Africa	8	8.03	7.57	2.07	2.09
	12	9.39	8.58	1.79	1.80
	1	3.10	3.25	1.91	2.49
Ghana	4	4.77	4.59	1.84	2.39
	8	7.02	6.36	2.06	2.77
	12	8.27	7.77	1.99	2.56

Table 1.4: Variance Decomposition for Commodity Price Shocks

		Full Period	**Before IT**	**During IT**
	Horizons		Output Growth	
	1	3.68	2.18	2.58
	4	4.11	6.13	8.43
South Africa	8	10.62	12.61	13.18
	12	13.88	14.66	16.32
	1	2.07	11.01	6.15
Ghana	4	4.62	13.19	19.44
	8	5.99	15.25	25.08
	12	6.37	15.86	25.96
		CPI-Inflation		
	1	1.41	11.36	2.35
	4	1.70	7.26	6.36
South Africa	8	3.66	8.23	12.74
	12	6.22	9.37	16.04
	1	0.59	1.22	4.42
Ghana	4	1.45	3.14	12.45
	8	3.22	7.57	19.02
	12	4.80	9.84	20.83
		Short-term Interest Rates		
	1	5.91	4.01	3.12
	4	9.36	9.15	6.60
South Africa	8	13.54	13.04	12.70
	12	15.14	14.46	16.32
	1	2.27	2.83	4.19
Ghana	4	5.74	6.00	9.86
	8	9.71	8.84	16.11
	12	12.25	11.05	18.08
		Real Credit		
	1	0.57	9.58	5.84
	4	1.97	7.68	9.14
South Africa	8	4.21	10.28	12.72
	12	8.31	12.35	15.35
	1	1.56	1.32	11.13
Ghana	4	5.01	4.90	19.59
	8	7.97	9.85	24.39
	12	8.66	11.08	26.13
		Real Effective Exchange Rates		
	1	3.66	9.06	2.60
	4	5.26	10.37	7.31
South Africa	8	10.60	14.04	12.92
	12	11.76	15.27	14.63
	1	8.38	11.14	17.43
Ghana	4	7.30	13.99	23.81
	8	9.23	16.29	30.10
	12	10.22	17.34	31.23

Table 1.5: Data used in the Nowcasting

Series	**Frequency**	**Sources**
Goods Exports (NSA, Mil.Rand)	Monthly	IMF, DOTS
Goods Imports (NSA, Mil.Rand)	Monthly	IMF, DOTS
Commodity exports	Monthly	Bank of Ghana
Commodity imports	Monthly	Bank of Ghana
Sales	Monthly	Bank of Ghana
Port Harbour Operations	Monthly	Bank of Ghana
Domestic VAT	Monthly	Bank of Ghana
Gross Domestic Product (SA, Mil.2006.Cedis)	Quarterly	Ghana Stat. Service
Real GDP growth	Yearly	IMF, WEO

1.6 Appendix: Nowcasting

The detailed exposition on nowcasting can be found in Giannone et al. (2008) and related studies.

A sequence of nowcasts of y_t^Q at different vintages $v, v+1; v+2$ is:

$$E\left[y_t^Q|\Omega_v\right]; E\left[y_t^Q|\Omega_{v+1}\right]; E\left[y_t^Q|\Omega_{v+2}\right]; \ldots$$

where E is the expectation operator and the Ω_v represent the information set used to make the forecast.

A Dynamic Factor Model (DFM) is employed to compute $E[\bullet|:]$. DFM can be summarizing the dynamic of N series can be written as follows:

$$X_t = \mu + \lambda f_t + \xi_t, \tag{1.6.1}$$

where $X_t = (x_{1,t}, \ldots, x_{N,t})'$, $\xi_t = (\xi_{1,t}, \ldots, \xi_{N,t})'$ is the vector of idiosyncratic component, $f_t = (f_{1,t}\ f_{2,t}, \cdots, f_{r,t})$ are the r common factors, and λ, is a $N \times r$ matrix of series-specific factor loadings. The model is estimated with the two-step approach proposed by Doz et al. (2011). The method relies on Kalman filter and Kalman smother which helps to estimate missing values. The latter occur because of the mixed frequency nature of the data set. For instance, a monthly definition of a quarterly data is one observation with two missing observations. Table 1.5 contains the data used.

Chapter 2

Empirical Framework for Macroeconomic Policies in Emerging Markets

2.1 Introduction

The welfare gains to stabilizing macroeconomic fluctuations are larger in emerging and developing countries then in advanced economies.[1] Yet substantially more effort has been put in developing such polices for advanced economies. A prerequisite for developing stabilization policies in emerging markets is to build structural models capable of explaining macroeconomic fluctuations. In developed economies, estimated dynamic stochastic general equilibrium (DSGE) models quantitatively match observed macroeconomic fluctuations (e.g. Smets and Wouters (2007) and Adolfson et al. (2007)). The same is not true of less developed economies. It is well known in the literature that estimated-SOE models have difficulties to account for the influence of foreign shocks. For instance, the predictions of the SOE-model in Justiniano and Preston (2010) suggest that US shocks only play a marginal role in macroeconomic fluctuation in Canada, a finding that is counterintuitive given the large degree of trade and financial linkages between the two countries and not consistent with the non-structural empirical literature. In related work Steinbach et al. (2009) apply the Justiniano and Preston (2010)'s model to South Africa and report that external shocks play no role in explaining fluctuations in South African GDP.

In this paper we build and estimate an open economy model that is capable of explaining the quantitative roles of external and domestic shocks in macroeconomic fluctuations in an emerging market. The application of our model is to the country of South Africa. In comparison with other BRICS countries, South Africa has a larger degree of openness to trade (60 versus 36% of GDP) and finance (159 versus 96% of GDP) which should make the relative roles these

[1] e.g. Pallage and Robe (2003) and Houssa (2013)

two elements play in the transmission of foreign shocks more transparent.[2] As a result of these international linkages business cycles in South Africa is strongly positively correlated with the one of G7 countries (57% between 1994 and 2016).[3]

The DSGE literature for emerging and developing economies has not been able to properly explain the stylized facts presented above. One strand of that literature has simply applied the models that were developed for advanced countries (e.g. Liu et al. (2009); Houssa et al. (2010); Steinbach et al. (2009); Alpanda et al. (2011); Gupta and Steinbach (2013) for South Africa) with no systematic account for their specificities. As a result, these studies have not been able to capture a number of important aspects of macroeconomic fluctuations in emerging and developing countries. For example, when confronting the SOE-DSGE model of Adolfson et al. (2007) with data we find that shocks originating from G7 countries explain no more than 6% of the variability in the South African GDP growth. Moreover, the model implies a weak co-movement between business cycles in South Africa and G7 countries. These findings are clearly counterintuitive given the stylized facts presented above. Indeed, empirical analysis using Structural Vector Autoregressive (SVAR) models show that (demand, supply, and credit) shocks originating from G7 countries and commodity price shocks play a dominant role (more than 30%) in macroeconomic fluctuations in South Africa (e.g. Houssa et al. (2015), Houssa et al. (2013)).

In this paper, we address these limitations by extending Adolfson et al. (2007)'s work in a number of dimensions that are empirically relevant to understand the transmission mechanisms of structural shocks originating from advanced countries (foreign block) to an emerging economy (domestic block). First, the economy is populated by three types of households: savers, entrepreneurs, and rule of thumbs (non-Ricardian) households that are excluded from financial markets (Mankiw (2000)). The inclusion of non-Ricardian households captures the role credit constraints plays in South Africa and this feature helps to better capture the high relative volatility of consumption (to income). In South Africa, 30% of the population (over 15 years) has no account at financial intermediaries.[4] Second, firms in the domestic and foreign blocks produce primary commodities and secondary products (or manufacturing goods) that are both traded. Domestic commodity supply is endogenous and fully exported. In particular, the primary commodity sector (essentially mining) is dominant in South Africa, accounting for about 40% of total trade in goods and services. The price of primary commodity is endogenously determined

[2]Trade openness is defined as the sum of exports and imports in goods and services and financial openness is measured by the sum of trade in assets and liabilities. The data for trade is for 2016 and come from the World Bank whereas the figures for financial openness are for the year 2011 and they are taken from and updated version of Lane and Milesi-Ferretti (2007).

[3]Two other elements motivate the choice of South Africa. First, the South African Reserve Bank operates in an inflation targeting framework allowing to explicitly model the behavior of the central. Second, South Africa is one of the very few few emerging market which possesses a large panel of macroeconomic series at quarterly frequency, allowing to have a good precision of the estimation.

[4]The comparative figure for advanced countries is 9% (World Bank Financial Inclusion Database)

in the foreign bloc and respond to foreign business cycles. Third, we introduce a financial sector comprising domestic and foreign banks. Banks collect deposits and provide loans to entrepreneurs and firms (e.g. Gerali et al. (2010)). Foreign banks are global players operating in the domestic and foreign markets (e.g. Kollmann (2013)). This feature is the key transmission channel of developments in the foreign credit market to the domestic economy. South Africa has a well developed and integrated banking sector with the rest of the world. Domestic credit to the private sector amounts to 145 of GDP (versus 91% for other BRICS) and the share of foreign bank assets among total bank assets in South Africa is similar to that of other OECD countries.[5] Within this rich model we define two broad categories of structural shocks. On the one hand, we have shocks of which origins (domestic or foreign) are clearly identified: supply, demand, credit, monetary, and commodity supply shocks. On the other hand, there are shocks for which the origins cannot be clearly identified: country risk premium shocks and other trade shocks. We label these shocks as SOE shocks.

We estimate the model with Bayesian methods using quarterly data from G7 countries and South Africa over the period 1994Q1 to 2016Q1. We provide a sub-period analysis and also experiment with different definitions of the foreign bloc (USA versus G7, where different measures of aggregate variables are used for the latter). The results show that the new model is capable of replicating the importance of foreign shocks seen in the reduced form empirical literature. In particular, foreign (demand, supply, monetary policy, credit supply, and commodity supply) shocks are important drivers of macroeconomic fluctuations in South Africa. For instance, they explain about 25% of the variability in real activity in South Africa. Domestic and SOE shocks also matter for macroeconomic fluctuation in South Africa. Domestic and SOE (trade and risk premium) shocks explain about 50 and 25% of fluctuation in the South African GDP, respectively. As such, any appropriate stabilization policy should take into account both these domestic and external (foreign and SOE) shocks. Historical decomposition also highlights their specific roles during key episodes such as the 2007/08 financial crisis and the commodity price slump in 2015. Moreover, we show that foreign shocks (except commodity supply) can replicate the observed strong positive co-movement between business cycles in G7 countries and South Africa.

Finally, we study the transmission channels of foreign shocks in South Africa in the new, quantitatively successful model. In particular, by shutting down channels one at a time in sequence, we find that the primary commodity sector plays an important role in the transmission of foreign shocks and that the credit channel has contributed to amplifying the fluctuations caused by commodity shocks. The ability of our model to capture endogenous responses of commodity and financial sectors to shocks originating from the foreign block is crucial to identify the importance of foreign shocks in South Africa. These results support the view

[5] 22% in 2006 in South Africa vs 27% for the OECD average but only 9% on average in other BRICS; see Claessens and Horen (2014). The data on domestic credit refer to 2016 and are obtained from the World Bank

that commodity prices are important driver of economic fluctuations in small open emerging economies (e.g. Mendoza (1995) and Kose (2002)). Recently, however, there has been a growing number of studies that challenge this view (e.g. Schmitt-Grohé and Uribe (2015), Fernandez et al. (2015), Drechsel and Tenreyro (2017), and Fernández et al. (2017)). Our paper contributes to this debate by proposing a framework that models the interactions between the commodity sector and other sectors in the domestic and foreign blocs. In existing SOE-DSGE studies commodity price (or term of trade) is assumed to be exogenous. We depart from this literature and allow commodity price to be driven both by commodity demand and commodity supply forces. Commodity demand forces capture endogenous response of commodity price to G7 (supply, demand, credit, and monetary) shocks whereas commodity supply shocks capture exogenous forces that affect the world commodity market. We find that G7 shocks account for about 48% of the variability in commodity price and the remaining 52% are driven by exogenous commodity supply shocks. The idea that commodity price can be explained by demand and supply forces is discussed in the SVAR literature (e.g. Kilian (2009)).

We argue that endogenous commodity sector responses is key to replicating business cycles synchronization between G7 countries and South Africa. For instance, a positive demand G7 shock would stimulate the demand for the commodity, which implies a rise in commodity price and in turn generates a boom in South Africa through its impacts on both the price and the demand for commodity. On the contrary, an exogenous commodity supply shock which increases the price of commodity will imply a negative co-movement between business cycles in South Africa and G7 countries because such a shock discourages real activities in G7 countries while at the same time it generates a boom in South Africa.

The remaining of the paper is structured as follows. Section 2 presents the extended model. Section 3 discusses the empirical strategy. Section 4 discusses the empirical results and the last section concludes.

2.2 Model

The model comprises two blocks, describing each the structure of one type of economy: a block for an emerging economy (domestic); and a block for advanced countries (foreign) which could be interpreted as the global economy. It is an extension of the SOE-DSGE model proposed by Adolfson et al. (2007), henceforth denoted as ALLV.[6] ALLV assume a one final-good sector model that includes a number of real and nominal rigidities (price and wage stickiness, investment adjustment costs, habits formation in consumption, and an incomplete exchange rate pass-through) in the domestic block. In addition, the domestic block includes fiscal and monetary authorities. Finally, they employ a SVAR model to capture the dynamics of the foreign

[6] Adolfson et al. (2007) builds on the closed economy DSGE model originally developed by Christiano et al. (2005).

block.[7]

We extend ALLV's model in a number of dimensions that are empirically relevant and allow to understand the transmission mechanisms of structural shocks originating from advanced countries to an emerging economy. In particular, we extend the domestic block to include a number of structural characteristics of an emerging economy. Moreover, we explicitly define the structure of the foreign block. The main ingredients of our extensions can be summarized in three points as follows. First, both the domestic and foreign economies produce two sorts of goods that are exported abroad: primary commodity and secondary goods. For this purpose, firms use a CES technology that combines labor, capital, and land (specifically for commodity). In addition, domestic firms use intermediate imported goods whereas foreign firms use commodity in the production process. Commodity is an homogeneous good that is produced under perfect competition. Its price is endogenously determined in the global market based on the demand for commodity by advanced countries and the world supply for commodity, which we assume to be exogenous. Domestic supply for commodity is also endogenous but it has no impacts on world commodity price given the SOE assumption. Secondary goods are also produced in a perfectly competitive environment but they are distributed by firms that enjoy market power. Distributors operate in three markets: domestic, import, and export. Second, we assume three categories of households allowing to capture key differences among savers, entrepreneurs, and financially constraint households (rule of thumb) but the latter are only included in the domestic block, as a simplifying assumption. Third, we introduce a financial sector comprising domestic and foreign banks. Banks collect deposits and provide loans to entrepreneurs and firms (e.g. Gerali et al. (2010)). Foreign banks are global players operating in the domestic and foreign markets (e.g. Kollmann (2013)).

The following sections describe our model in details. The first order conditions, its steady state and observation equations are presented in the appendix.

2.2.1 Households

The domestic economy is populated by three types of households: savers, entrepreneurs and rule of thumb consumers. Savers accumulate wealth in the form of domestic and foreign financial assets whereas entrepreneurs manage domestic firms and invest to build physical capital used in the production sectors. Finally, rule of thumb households are excluded from the financial markets and they are unable to accumulate wealth. They mimic the savers for their labor effort decisions and consume their entire income in each period. The household mass is normalized to 1 for each type of households.

Households derive utility from the consumption of a composite good (consisting of domes-

[7] In Adolfson et al. (2007) the Euro area is the domestic economy whereas the foreign economy is an aggregate of four countries (US, UK, Japan and Switzerland).

tic and imported goods). Aggregate consumption $C_{j,t}$ for any household j is given by the CES index of domestic and imported goods

$$C_{j,t} = \left[(1-\varepsilon_{m,t}\omega_c)^{1/\eta_c}(C^d_{j,t})^{(\eta_c-1)/\eta_c} + (\varepsilon_{m,t}\omega_c)^{1/\eta_c}(C^m_{j,t})^{(\eta_c-1)/\eta_c}\right]^{\eta_c/(\eta_c-1)}, \qquad (2.2.1)$$

where $C^d_{j,t}$ and $C^m_{j,t}$ denote consumption of the domestic and imported good, respectively, ω_c is the (steady-state) share of imports in consumption, and η_c is the elasticity of substitution between domestic and foreign consumption goods. The exogenous process $\varepsilon_{m,t}$ represents a preference shock on imported goods.

Savers

Household optimization problem The representative saver maximizes the inter-temporal utility by choosing her consumption level, labour effort, and domestic as well as foreign financial asset holdings.[8] The j^{th} household's preferences are given by

$$\mathrm{E}_0^j \sum_{t=0}^{\infty} \beta_S^t \left[\frac{\left(C_{j,t} - \mathbf{b}C_{t-1}\right)^{1-\sigma_c}}{1-\sigma_c} - A_h \frac{(h_{j,t})^{1+\sigma_h}}{1+\sigma_h}\right], \qquad (2.2.2)$$

where E is the expectation operator and $h_{j,t}$ denotes work effort. The parameters σ_c and σ_h denote the inverse of the inter-temporal elasticity of substitution for consumption and the inverse of the elasticity of work effort, respectively; A_h is the relative importance of labour in the utility; **b** is the exogenous habit parameter and β_S is the discount factor of savers.

They work, consume, and save in domestic and foreign risk-free financial assets. For any given period t, savers face the same budget constraint which is given, in nominal terms, by

$$\begin{aligned} B_{j,t+1} + S_t B^*_{j,t+1} + P^c_t C_{j,t}(1+\tau^c) &= TR^s_t + SCS_{j,t} \\ +(1-\tau^y)\frac{W_{j,t}}{1+\tau^w}h_{j,t} + \varepsilon_{b,t-1}R_{t-1}B_{j,t} &+ \varepsilon_{b,t-1}R^*_{t-1}\Phi(\frac{A_{t-1}}{z_{t-1}},\tilde{\phi}_{t-1})S_t B^*_{j,t} \qquad (2.2.3) \\ -\tau^k[(\varepsilon_{b,t-1}R_{t-1}-1)B_{j,t} + (\varepsilon_{b,t-1}R^*_{t-1}\Phi(\frac{A_{t-1}}{z_{t-1}},\tilde{\phi}_{t-1}) &- 1)S_t B^*_{j,t} + B^*_{j,t}(S_t - S_{t-1})], \end{aligned}$$

where the subscript j indicators denote the household's choice variables, whereas the uppercase variables, without the subscript, are the economy-wide aggregates. B_t denotes the value of nominal domestic assets, S_t is the nominal exchange rate defined as the amount of the local currency per unit of foreign currency and B^*_j is the value of foreign assets (expressed in foreign

[8] The domestic financial market is assumed to be complete, thus each household can insure against any type of idiosyncratic risk through the purchase of the appropriate portfolio of securities. This prevents the frictions from causing the households to become heterogeneous, so the representative agent framework is still valid for this economy.

currency). TR_t^s denotes lump-sum transfers from the government, $SCS_{j,t}$ is the household's net cash income from participating in state contingent securities at time t. P_t^c is the consumer price index and W_t represents the wage rate. P_t is the producer price of the domestic secondary good.

The government finances its expenditures by collecting pay-roll tax and taxes on consumption, labour and capital: τ^c is consumption tax, τ^w is pay-roll tax, τ^y is labour-income tax, and τ^k is capital-income tax. R_t and R_t^* are gross domestic and foreign policy rates determined by the domestic and foreign central banks, respectively. The exogenous process $\varepsilon_{b,t}$ creates a wedge between the monetary policy rate and the return on asset held by savers (e.g. Smets and Wouters (2007)).[9]

Country risk premium In Equation (2.2.3) the term $R_{t-1}^*\Phi(A_{t-1}/z_{t-1}, \tilde{\phi}_{t-1})$ represents the risk-adjusted pre-tax gross interest rate paid by foreign bonds (in foreign currency). The term $\Phi(\frac{A_t}{z_t}, \tilde{\phi}_t)$ captures the country risk premium which is a function of the real aggregate net foreign asset position $A_t \equiv \frac{S_t B_{t+1}^*}{P_t}$.[10] It is made stationary using the level of permanent technology z_t and $\tilde{\phi}_t$ is a time varying shock to the risk premium.

This function $\Phi(.,.)$ illustrates the imperfect integration of domestic economy in international financial markets.[11] Therefore, domestic households are charged a premium over the (exogenous) foreign interest rate R_t^* if the domestic economy is a net borrower $(B_t^* < 0)$, and it receives a lower remuneration on their savings if the domestic economy is a net lender $(B_t^* > 0)$.

Wage setting Every household (except entrepreneurs) is a monopoly supplier of a differentiated labour service and sets its own wage $W_{j,t}$ with an adjustment rule à-la Calvo. It sells its labour services $(h_{j,t})$ to a labour packer which transforms it into a homogeneous input good H using the following production function

$$H_t = \left[\int_0^1 (h_{j,t})^{\frac{1}{\lambda_{w,t}}} dj\right]^{\lambda_{w,t}}, \ 1 \leq \lambda_{w,t} < \infty, \tag{2.2.4}$$

where $\lambda_{w,t}$ is a time-varying wage mark-up. This labour packer takes the input price of the j^{th} differentiated labour input as given, as well as the price of the homogeneous labour services.

Households have a probability $(1-\xi_w)$ to be allowed to re-optimize their wages. Those that cannot re-optimize their wages follow an indexation mechanism described by

$$W_{j,t+1} = \left(\pi_t^c \frac{\Delta y_t}{\Delta H_t}\right)^{\kappa_w} (\bar{\pi})^{1-\kappa_w} \mu_z W_{j,t},$$

[9] This shock acts as an aggregate demand shock by affecting households consumption and investment decisions. We additionally introduce proper credit supply shocks affecting entrepreneurs lending rates (see the financial sector section).

[10] The function $\Phi(\frac{A_t}{z_t}, \tilde{\phi}_t) = \exp(-\tilde{\phi}_A(\frac{A_t}{z_t} - \overline{A}) + \tilde{\phi}_t)$ is strictly decreasing in A_t and satisfies $\Phi(\frac{A}{z}, 0) = 1$.

[11] It also helps to make the model stationary; see Schmitt-Grohé (2003).

such that they index their wages to a combination of factors including: the last period consumer price inflation $\pi_t^c = \frac{P_t^c}{P_{t-1}^c}$; the last period transitory labour productivity growth $\frac{\Delta y_t}{\Delta H_t}$ where $y_t = \frac{Y_t}{z_t}$ and Y_t is GDP; the inflation target rate $\bar{\pi}$; and permanent technology growth $\mu_z = \frac{z_{t+1}}{z_t}$.[12] The wage-indexation parameter κ_w determines the relative importance of past consumer price inflation and labour productivity growth in the indexation process.

Labour mobility We assume imperfect labour mobility between primary and secondary sectors similarly to Horvath (2000) and Dagher et al. (2010).[13] The labour aggregator allocates labour between primary and secondary sectors. Total labour effort is given by a CES aggregation of hours worked in the primary and secondary sectors

$$H_t = \left[(1-\omega_h)^{-1/\eta_h}(H_t^f)^{(1+\eta_h)/\eta_h} + \omega_h^{-1/\eta_h}(H_t^p)^{(1+\eta_h)/\eta_h}\right]^{\eta_h/(1+\eta_h)}, \tag{2.2.5}$$

where H_t^p and H_t^f denote labour effort in the primary and final sectors, respectively; ω_h is the share of primary sector employment in total employment; and η_h is the elasticity of substitution between labour services provided in the two sectors. The intuition behind this specification is that there are costs associated to labour mobility such as sector specific skills.[14]

Rule of thumb households

There is a continuum of rule of thumb households of mass 1 indexed by $j \in (0,1)$. They are similar to non-ricardian households developpped in Coenen and Straub (2005), Erceg et al. (2006) and Galí et al. (2007) and introduced in DSGE models applied to developing countries (as for e.g. in Medina and Soto (2007) and Céspedes et al. (2012)). They do not have access to credit and capital markets. They consume their entire labour income in every period. Their budget constraint is given by

$$(1+\tau_t^c)P_t^c C_{j,t} = \frac{1-\tau_t^y}{1+\tau_t^w} W_{j,t} h_{j,t} + TR^r , \tag{2.2.6}$$

where TR^r are government transfers. Those households mimic savers in setting their wage and labour effort.

[12] The indexation to transitory productivity growth ensures a standard response of consumption to stationary technology shocks in our model where rule of thumbs households consumption depends on labour market incomes. We assume that the permanent technology growth rate is constant and calibrated to μ_z.

[13] Using a panel of OECD countries, Cardi and Restout (2015) argue that sector specific productivity shocks generate wage differential incompatible with perfect labour mobility. They show that Horvath (2000) labour allocation function can replicate this wage gap.

[14] Fedderke (2012) argues that the South African labour market is rigid. It is segmented (between unionised and non-unionised workers and between the formal and informal sector) and suffers from skills mismatch.

Entrepreneurs

Optimization problem There is a continuum of entrepreneurs (e.g. Gerali et al. (2010)) of mass 1, indexed by $j \in (0,1)$, which attain utility from consumption. Their inter-temporal utility is given by

$$\mathrm{E}_0^j \sum_{t=0}^{\infty} \beta_E^t \left[\frac{\left(C_{j,t} - \mathbf{b}C_{t-1}\right)^{1-\sigma_c}}{1-\sigma_c} \right], \tag{2.2.7}$$

where $\beta_E < \beta_S$ ensures that entrepreneurs are more impatient than savers. Entrepreneurs consume, borrow in domestic assets (from the bank), and manage (both primary and secondary sectors') firms. They pay wages to savers and rule of thumb households, purchase foreign inputs, manage capital stocks and sell (primary and final) output. Entrepreneurs maximize this utility under a budget constraint presented below after a discussion on investment and capital accumulation.

Investment and capital accumulation Capital and investment are assumed to be sector specific. The investment (I^q) in each sector $q \in (p, f)$ -p for primary sector and f for secondary sector- is given by a CES aggregate of domestic ($I_t^{d,q}$) and imported investment goods ($I_t^{m,q}$) in each sector

$$I_t^q = \left[(1-\varepsilon_{m,t}\omega_i)^{1/\eta_i} (I_t^{d,q})^{(\eta_i-1)/\eta_i} + (\varepsilon_{m,t}\omega_i)^{1/\eta_i} (I_t^{m,q})^{(\eta_i-1)/\eta_i} \right]^{\eta_i/(\eta_i-1)}, \tag{2.2.8}$$

where ω_i is the share of imports in investment and η_i is the elasticity of substitution between domestic and imported investment goods.

The capital accumulation rule is subject to investment adjustment costs and follows

$$\overline{K}_{t+1}^q = (1-\delta)\overline{K}_t^q + \Upsilon_t F(I_t^q,\, I_{t-1}^q) + \triangle_t^{k,q}\ , \tag{2.2.9}$$

where δ is the depreciation rate and the variable $\triangle_{k,q}$ reflects the fact that capital producers have access to a market where they can purchase or sell new, installed capital in the primary and secondary sectors at prices $P_t^{k,p}$ and $P_t^{k,f}$, respectively.[15] Υ_t is a stationary investment-specific technology shock common to both sectors and $F(I_t, I_{t-1})$ represents a function which turns investment into physical capital. The $F(I_t, I_{t-1})$ function is specified following Christiano et al. (2005) as

$$F(I_t,\, I_{t-1}) = (1-\tilde{S}(I_t/I_{t-1}))I_t\ , \tag{2.2.10}$$

[15] In equilibrium it will be the case that $\triangle_t = 0$, since all entrepreneurs are identical.

where the function $\tilde{S}(I_t/I_{t-1})$ is defined by

$$\tilde{S}(I_t/I_{t-1}) = \phi_3^i \left\{ exp\left(\frac{I_t}{I_{t-1}} - \mu_z\right) + exp\left(-\frac{I_t}{I_{t-1}} + \mu_z\right) - 2 \right\}, \tag{2.2.11}$$

with $\tilde{S}(\mu_z) = \tilde{S}'(\mu_z) = 0$ and $\tilde{S}''(\mu_z) \equiv \tilde{S}'' = 2\phi_3^i > 0$.

Entrepreneurs also set the rate of capital utilisation such that the effective capital stock available to the firms in each sector q is given by

$$K_t^j = u_t^q \overline{K}_{t+1}^q \,. \tag{2.2.12}$$

In Equation (2.2.14), the function $a(u_t^q)$ follows Christiano et. al. (2005) and is defined as

$$a(u_t^q) = \frac{(1-\tau_k) r_k}{\sigma_a} \left(\exp\left(\sigma_a (u_t^q - 1)\right) - 1\right), \tag{2.2.13}$$

with $a'(u) = (1-\tau_k) r_k$ and $a''(u) > 0$.

Budget constraint Entrepreneurs face the following budget constraint

$$P_t^c C_{j,t}(1+\tau^c) + P_t^i \left(I_{j,t}^p + I_{j,t}^f\right) + R_{t-1}^L B_{j,t}^e + P_t \left(a(u_{j,t}^p)\bar{K}_{j,t}^p + a(u_{j,t}^f)\bar{K}_{j,t}^f\right)$$

$$= (1-\tau^k)\Pi_{t,j} + \tau^k (R_{t-1}^L - 1) B_{j,t}^e + B_{j,t+1}^e + TR_{j,t}^e + SCS_{j,t}^e + P_t^{k,p} \triangle_{j,t}^{k,p} + P_t^{k,f} \triangle_{j,t}^{k,f}\,, \tag{2.2.14}$$

with

$$\begin{aligned} \Pi_t, j = {} & P_t Y_{j,t}^f + (S_t P_t^x - (1-\omega_x) P_t - \omega_x P_t^m) X_{j,t}^f + \left(S_t P_t^{*p} - \omega_x P_t^m\right) X_{j,t}^p \\ & - R_{t-1}^L \left(W_t^p H_{j,t}^p + W_t^f H_{j,t}^f\right) - \left(\nu_n R_{t-1}^L + 1 - \nu_n\right) P_t^m N_{j,t}^m - z_t \phi, \end{aligned} \tag{2.2.15}$$

where in Equation (2.2.14) the terms $P_t^c C_t$ and $P_t^i (I_t^p + I_t^f)$ represent total consumption and investment spendings, respectively. Entrepreneurs invest I_t^f in capital $\bar{K}_t^f$ used in the secondary sector and I_t^p in capital $\bar{K}_t^p$ used in the primary sector. They are charged a lending rate R_{t-1}^L (discussed in the financial sector section below) on credit B_t^e carried over from the previous period. Entrepreneurs use this credit to finance their wage bill $(W_t^p H_{j,t}^p + W_t^f H_{j,t}^f)$ and a share ν_n of their expenditures on imported inputs $(P_t^m N_{j,t}^m)$, which is expressed in domestic currency. The functions $a(u_t^p)$ and $a(u_t^f)$ represent the cost of varying capital utilisation rate in both sectors. The variables $\triangle_{j,t}^{k,p}$ and $\triangle_{j,t}^{k,f}$ reflect the fact that capital producers have access to a market where they can purchase or sell new, installed capital in the primary and secondary sectors at prices $P_t^{k,p}$ and $P_t^{k,f}$, respectively. The terms $TR_{j,t}^e$ and $SCS_{j,t}^e$ represent transfers and state contingent securities.[16]

[16]Assuming state contingent securities helps to avoid heterogeneity that could otherwise arise from price stickiness.

In Equation (2.2.15), entrepreneurs' profits $\Pi_{t,j}$ depends on sales and production costs. The production function Y_t^f is presented in the firms section below. X_t^p and X_t^f represent exports of primary and final goods, respectively, and ω_x is the import content of exports. The term $z_t\phi_t$ defines fixed costs (paid in monetary terms) that ensures that the free entry condition holds in the secondary sector.[17]

2.2.2 Firms

There are two categories of goods in this model: primary commodity (essentially mining); and secondary goods.

Commodity sector

Primary commodity is produced under perfect competition in the two blocks of the model.

Domestic commodity The domestic commodity supply is assumed to be entirely exported abroad allowing to capture the dominant role it plays in the exports of this emerging economy. It is produced in two stages. First, firms combine capital, labour and land to produce a commodity input Y_t^p with a CES technology

$$Y_t^p = Y_0^p \left[\alpha_p \left(\frac{\varepsilon_{k,t} K_t^p}{K_0^p} \right)^{\frac{\sigma_p - 1}{\sigma_p}} + \beta_p \left(\frac{z_t L_t^p}{L_0^p} \right)^{\frac{\sigma_p - 1}{\sigma_p}} + (1 - \alpha_p - \beta_p) \left(\frac{z_t H_t^p}{H_0^p} \right)^{\frac{\sigma_p - 1}{\sigma_p}} \right]^{\frac{\sigma_p}{\sigma_p - 1}} \quad (2.2.16)$$

where K_t^p is capital stock and H_t^p represents labour services used in the mining sector. L_t^p is amount of land used for commodity production. Land is assumed to be exogenous with respect to commodity price.[18] In particular, we assume the following AR(1) process $L_t^p = \delta_l L_{t-1}^p + \varepsilon_{L,t}$, where $\varepsilon_{L,t}$ is an IID process for commodity supply shock in the domestic economy. α_p and β_p are income shares of capital and land in the primary sector, respectively; σ_p is the elasticity of substitution between production factors in the primary sector; and $\varepsilon_{k,t}$ is a capital augmenting technology shock.

In the second step commodity producers use a Leontief Technology to combine the commodity input Y_t^p with an imported input (capturing the import content of exports)

[17] We assume that $\phi_t = (1 - \frac{1}{\lambda_{d,t}})Y_0^f$ which ensures that the free entry condition holds in the long run for a given mark-up $\lambda_{d,t}$ with Y_0^f denoting is the steady state value of the production discussed in the firm section. It allows the fixed costs to adjust to changes in the final goods distributors market powers and therefore prevents dramatic changes in firms profits after a mark-up shock, which would otherwise transmits to entrepreneurs' balance sheets and risk-premiums.

[18] Exogenous land helps to control the transmission of highly volatile commodity price to the domestic economy (e.g.Kose (2002)).

$$X_t^p = \min\left(\frac{Y_t^p}{1-\omega_x}, \frac{N_t^x}{\omega_x}\right), \tag{2.2.17}$$

where X_t^p represents domestic commodity production and N_t^x is the import content of commodity exports. Domestic commodity is entirely exported abroad at the world price of commodity P_t^{*p} which is determined by foreign demand and supply for commodity.[19] Note, however, that the domestic commodity supply is allowed to respond to world commodity price. This is an important channel through which foreign shocks impact on the domestic economy. Endogenous domestic commodity production is also assumed in the literature (e.g. Kose (2002) and Hove et al. (2015)) but our framework is distinctive in the inclusion of intermediate inputs. The latter allows to account for the empirical relevance of the imports content of exports.

Foreign commodity World commodity price is determined endogenously through the confrontation of the foreign supply (Y_t^{pS*}) and foreign demand (Y_t^{pD*}) for commodity. Foreign commodity supply is modelled as an exogenous AR(1) process

$$Y_t^{pS*} = \delta_{pS}^* Y_{t-1}^{pS*} + \varepsilon_{pS,t}^*, \tag{2.2.18}$$

where $\varepsilon_{pS,t}^*$ is the foreign commodity supply shock which is assumed to be an IID process. This shock could be also interpreted as a pure commodity price shock hitting the world commodity price for reasons that are unrelated to world commodity demand.

The foreign demand for commodity is determined by the foreign secondary good sector where it served as inputs. Two steps are involved in the production of foreign secondary goods. First, foreign firms combine capital and labour to produce a foreign intermediate good using a CES technology

$$N_t^* = N_0^* \left[\alpha^* \left(\frac{\varepsilon_{k,t}^* K_t^*}{K_0^*}\right)^{\frac{\sigma_d^*-1}{\sigma_d^*}} + (1-\alpha^*)\left(\frac{z_t H_t^*}{H_0^*}\right)^{\frac{\sigma_d^*-1}{\sigma_d^*}}\right]^{\frac{\sigma_d^*}{\sigma_d^*-1}}, \tag{2.2.19}$$

where H_t^* is hours worked and K_t^* is capital. The parameter σ_d^* is the elasticity of substitution between labour and capital and $\varepsilon_{k,t}^*$ is a capital efficiency shock. In the second step, foreign firms combine this intermediate good with their demand for commodity to obtain secondary

[19] In line with the SOE assumption, the domestic economy supply is too small to influence the world commodity price. This assumption is likely to hold looking at South African shares in commodity exports such as gold (3.3% in 2015, OEC), diamonds (8.7%), coal briquettes (7.7 %), Iron Ore (5%) and aluminium (2.6%) with the exception of Platinum (41%). Formally, Broda (2004) tests the term of trade exogeneity assumption on a sample of 1000 goods in 75 developing countries including South Africa. He finds that only 22 goods from 9 countries violate this assumption, none of which originating from South Africa.

foreign goods

$$Y_t^* = Y_0^* \left[\beta^* \left(\frac{Y_t^{pD*}}{Y_0^{pD*}} \right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} + (1-\beta^*) \left(\frac{N_t^*}{N_0^*} \right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} \right]^{\frac{\sigma_p^*}{\sigma_p^*-1}}, \tag{2.2.20}$$

where Y_0^{pD*} and N_0^* are normalizing constants; β^* is the (income) share of commodity in foreign secondary goods sector; and σ_p^* is the elasticity of substitution between commodity and foreign intermediate good. Equation (2.2.20) shows how foreign (supply, demand, credit, and monetary policy) shocks could be transmitted to the domestic economy through commodity prices. Indeed, a boom in the foreign economy cause an increase in commodity demand which eventually raises commodity prices. The elasticity σ_p^* is a key parameter that determines the strength of commodity price responses to changes in foreign demand for commodity.

Secondary sector

Domestic and foreign secondary goods are used for domestic and foreign consumption and investment as imperfect substitutes. In addition, foreign secondary goods enter the domestic production function as inputs. The structure of the secondary sector can be organized in three steps: *i)* Secondary good firms produce an un-differentiated secondary good; *ii)* Distributors (in the domestic, export, and import markets) differentiate secondary good with brand-naming technology. They enjoy monopoly power which we model as the Calvo price setting; and *iii)* Aggregators assemble the un-differentiated goods into consumption and investment goods as well as in inputs.

Secondary good firms The secondary good is produced under perfect competition. Firms use capital K^f, purchase foreign inputs N^m and hire labour H^f to produce an undifferentiated secondary good denoted by Y^f. Two steps are involved. First, firms combine labour and capital to produce a domestic input using a CES technology following Cantore et al. (2014)

$$N_t^d = N_0 \left[\alpha \left(\frac{\varepsilon_{k,t} K_t^f}{K_0} \right)^{\frac{\sigma_d-1}{\sigma_d}} + (1-\alpha) \left(\frac{z_t H_t^f}{H_0} \right)^{\frac{\sigma_d-1}{\sigma_d}} \right]^{\frac{\sigma_d}{\sigma_d-1}}, \tag{2.2.21}$$

where z_t is a unit-root technology process growing at a constant rate μ_z representing labour productivity; $\varepsilon_{k,t}$ represents a capital augmenting technology shock whic is assumed to be common to the primary and secondary sectors; N_0 is a normalizing constant, which is defined in the steady state appendix. The parameter σ_d represents the elasticity of substitution between labour and capital. If σ_d=1 this functional form leads to the standard Cobb-Douglas production function. The CES function is written in its normalised form as in Temple (2012) and Cantore and Levine (2012). This specification ensures that the coefficient α is the true labour income share.

In the second step, secondary producers combine domestically produced inputs with imported inputs to create the secondary good using the following CES function:

$$Y_t^f = Y_0^f \left[\varepsilon_{m,t}\omega_n \left(\frac{N_t^m}{N_0^m} \right)^{\frac{\sigma_n - 1}{\sigma_n}} + (1 - \varepsilon_{m,t}\omega_n) \left(\frac{N_t^d}{N_0^d} \right)^{\frac{\sigma_n - 1}{\sigma_n}} \right]^{\frac{\sigma_n}{\sigma_n - 1}}, \tag{2.2.22}$$

where σ_n is the elasticity of substitution between domestic and foreign inputs (Burstein et al. (2008)), Y_0^f is a scaling parameter.

Domestic distributors There are two types of domestic distributors (intermediate and final). There is a continuum of intermediate distributors, indexed by $i \in [0,1]$. Each intermediate distributor buys a homogeneous secondary good Y^f; turns it into a differentiated intermediate good (using a brand naming technology) and then sells it to a final distributor at price $P_{i,t}$. Every intermediate distributor is assumed to be a price taker in the secondary good markets (it purchases secondary goods at their marginal costs) and a monopoly supplier of its own variety (it sets its own price). The final distributor is an aggregator which uses a continuum of differentiated intermediate goods to produce the final homogeneous good, which is then used for consumption and investment by domestic households and sold at price P_t.

The intermediate distributor follows a price adjustment rule à-la Calvo (1983). Every period t, with probability $(1 - \xi_d)$, any intermediate distributor i is allowed to re-optimize its price by choosing the optimal price P_t^{new}.[20] With probability ξ_d, it cannot re-optimize, and it simply indexes its price for period $t+1$ according to the following rule:

$$P_{i,t+1} = (\pi_t)^{\kappa_d} (\overline{\pi})^{1-\kappa_d} P_t,$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is last period's inflation, $\overline{\pi}$ is the inflation target and κ_d is an indexation parameter.

The final distributor is assumed to have the following CES production function:

$$J_t^d = \left[\int_0^1 \left(J_{i,t}^d \right)^{\frac{1}{\lambda_{d,t}}} di \right]^{\lambda_{d,t}}, \; 1 \leq \lambda_{d,t} < \infty, \tag{2.2.23}$$

where $J \in (C, I)$ refers to the consumption or investment good and $\lambda_{d,t}$ is a stochastic process determining the time-varying markup in the domestic goods market.

[20]Since all distributors are virtually identical and they will always choose the same price the index i is dropped to simplify the notation.

Exporting distributors The intermediate exporting firm buys a homogeneous domestic good Y^f to domestic secondary producers as well as a foreign input (to importing firms at price P_t^m) to account for import content of exports.[21] It combines these goods using a Leontief technology, turns them into a type specific differentiated good using a brand naming technology and then sells it in the foreign market to an aggregator at price $P_{i,t}^x$ expressed in foreign currency. The aggregator produces final exported consumption and investment goods sold at price P_t^x to foreign households.

The final, composite, exported good aggregates a continuum of i differentiated exported goods, each supplied by a different firm, according to

$$\tilde{X}_t = \left[\int_0^l (\tilde{X}_{i,t})^{\frac{1}{\lambda_x}} di\right]^{\lambda_x}, \ 1 \leq \lambda_x < \infty. \tag{2.2.24}$$

where λ_x is the steady-state mark-up in the exporting sector.

Domestic intermediate exporting firms follow a Calvo price setting rule and can optimally change their price only when they receive a random signal. In any period t, each exporting firm has a probability $(1-\xi_x)$ to re-optimize its price by choosing $P_{new,t}^x$.[22] With probability ξ_x the importing firm cannot re-optimize at time t and, instead, it indexes its price according to the following scheme: $P_{t+1}^x = (\pi_t^x)^{\kappa_x}(\overline{\pi})^{1-\kappa_x}P_t^x$ where $\pi_t^x = \frac{P_t^x}{P_{t-1}^x}$. This foreign currency price stickiness assumption implies short run incomplete exchange rate pass-through to the export price.

Assuming that aggregate foreign consumption and investment follow a CES function, foreign demand for the aggregate final exported good is defined by

$$X_t^f = \left(\frac{P_t^x}{P_t^*}\right)^{-\eta_f} X_t^*, \tag{2.2.25}$$

$$X_t^* = X^*\left(\frac{\omega_1 C_t^* + (1-\omega_1)I_t^*}{\omega_1 C^* + (1-\omega_1)I^*}\right)\varepsilon_{x,t}, \tag{2.2.26}$$

where P_t^* is the price of the foreign good in foreign currency, P_t^x is the export price (denominated in export market currency) and X_t^* is foreign demand function of foreign consumption and investment where ω_1 is the share of consumption in final good trade. $\varepsilon_{x,t}$ is an export specific shock. The coefficient η_f is the foreign elasticity of substitution between foreign and domestic goods allowing for short run deviations from the law of one price.

Importing distributors The (foreign owned) intermediate importing firm buys a homogeneous foreign good in the world market. It turns it into a type specific good using a differentiating technology (brand naming) and then sells it in the domestic market to an aggregator at

[21] Estimated to 19.5% in South-Africa in 2011 by the OECD.

[22] All exporting firms that are allowed to re-optimize their price, in a given period, will choose the same price, therefore it is not necessary to use a firm index.

price $P^m_{i,t}$. The aggregator produces final imported consumption, investment and input goods sold at price P^m_t to households and firms.

The final imported consumption and investment goods are aggregated using a continuum of i differentiated imported goods. Each are supplied according to

$$J^m_t = \left[\int_0^l (J^m_{i,t})^{\frac{1}{\lambda_{m,t}}} di \right]^{\lambda_{m,t}}, \; 1 \leq \lambda_{m,t} < \infty, \tag{2.2.27}$$

where $\lambda_{m,t}$ is the time varying markup common to all sectors J and $J \in (C, I, N)$ is an indices referring to the imported consumption, investment and input goods. We assume that this mark-up is affected by both foreign mark-up shocks (common to all foreign distributors) as well as by a specific import price push shock.

Foreign intermediate importing firms follow a Calvo price setting rule and can optimally change their price only when they receive a random signal. In any period t, each importing firm has a probability $(1-\xi_m)$ to re-optimize its price by choosing $P^m_{new,t}$[23]. With probability ξ_m the importing firm cannot reoptimize at time t and, instead, it indexes its price according to the following scheme: $P^m_{t+1} = (\pi^m_t)^{\kappa_m}(\overline{\pi})^{1-\kappa_m} P^m_t$ where $\pi^m_t = \frac{P^m_t}{P^m_{t-1}}$. This local currency price stickiness assumption implies incomplete exchange rate pass-through to the consumption and investment import prices.

We depart from Adolfson et al. (2007) by assuming that the imported good price is the same for both investment and consumption. We also assume that a share of imports are used by domestic producers and exporting firms. In addition, the domestic importing firm purchases the foreign input at its marginal production cost.

2.2.3 Financial sector

There are two types of banks: domestic and foreign.[24] Domestic banks operate in the domestic market. Foreign banks are global players (similarly to Kollmann (2013)) operating in the domestic and foreign markets. Developments in the financial sector have repercussions on both the aggregate demand (through entrepreneurs consumption and investment) and supply (through firms working capital paid in advance) sides of the model. Entrepreneurs take loans denominated in domestic currency at aggregate rate R^L_t given by

$$R^L_t = (1-\omega_b) R^{L,d}_t + \omega_b R^{L,f}_t \;, \tag{2.2.28}$$

[23] All importing firms that are allowed to re-optimize their price, in a given period, will choose the same price, therefore it is not necessary to use a firm index.

[24] Cetorelli and Goldberg (2011) show that both foreign and domestic banks contributed to the transmission of the financial crisis to emerging countries in Europe, Asia and Latin America. Cross border lending and local loans by foreign affiliates were cut while domestic banks also reduced their loans due to adverse balance sheet effects resulting from the financial crisis. Although no African countries are considered, it justifies the introduction of domestic and foreign banks in the model.

where ω_b is the share of foreign banks operating in the domestic economy. $R_t^{L,d}$ and $R_t^{L,f}$ are the lending rates charged by domestic and foreign banks to domestic borrowers, respectively. In particular, we assume that each entrepreneur borrows a fixed share ω_b of their credit needs from foreign banks and that they cannot take advantage of arbitrage opportunities. We define these lending rates below.

Domestic financial market Domestic banks collect deposits from savers and have access to the central bank to finance any liquidity shortage. The deposit rate is equal to the return on other savers assets. It is set to $\varepsilon_{b,t}R_t$ where R_t is the central bank rate and $\varepsilon_{b,t}$ is a wedge shock. Banks give loans to entrepreneurs (e.g. Gerali et al. (2010)). Following Bernanke et al. (1999), we assume the existence of an agency problem (not modelled here) between banks and borrowers. The domestic bank determines the domestic lending rate $R_t^{L,d}$ and charges an external financing premium over the deposit rate to finance monitoring costs by setting

$$R_t^{L,d} = \varepsilon_{b,t}R_t \exp\left[\phi_{nw}\left(\frac{B_t^e}{V_t} - \frac{B^e}{V}\right)\right] + \varepsilon_{R_L,t} \;, \tag{2.2.29}$$

where B_t^e is the entrepreneur nominal debt and V_t is its net worth such that $\frac{B_t^e}{V_t}$ represents leverage. $\varepsilon_{R_L,t}$ is a domestic credit supply shocks. Therefore, the domestic bank spread between lending and deposit rates depends on the endogenous evolution of domestic entrepreneurs balance sheets and to a pure credit supply shocks.[25] We depart from Bernanke et al. (1999) by considering an alternative definition of the net worth. We draw on Mendoza (2002) and define the net worth as

$$V_t = P_tY_t^f + S_tP_t^{*p}X_t^p \;, \tag{2.2.30}$$

where $P_tY_t^f$ is nominal output in the final sector, $S_tP_t^{*p}$ is the commodity price expressed in domestic currency and X_t^p represents commodity exports. This specification has been widely used in the sudden stop literature applied to developing countries subject to term of trade shocks. Arellano and Mendoza (2002) argue that it reflects actual practice in the credit markets.[26]

Foreign financial market Foreign banks determine the lending rates they charge to domestic and foreign entrepreneurs. For simplicity and to allow for some add-hoc transmission mechanism we assume that foreign banks set the same risk premium in both markets. They consider

[25] In spirit, the pure credit supply shock identification si similar to Helbling et al. (2011) and Meeks (2012): it is an increase in the credit spread unrelated to default risks. It generates a gap between the lending and deposit rates. It differs from the wedge shock $\varepsilon_{b,t}$ which causes a gap between the central bank policy rate and the private rates (including both lending and deposit rates).

[26] They argue that a higher current income to credit ratio "reduces the likelihood of observing situations in which the current income of borrowers falls short of what is needed to pay for existing debts". Although we do not introduce sudden stops (none were observed in South Africa over the estimation period, see Smit et al. (2014)), we use this argument in order to link credit spreads to a similar ratio.

global (the sum of domestic and foreign) entrepreneurs balance sheets to set an identical premium over the domestic and foreign deposit rates. Foreign banks set the lending rate

$$R_t^{L,f} = \varepsilon_{b,t} R_t \exp\left[\phi_{nw}^* \left(\frac{B_t^{e*}}{V_t^*} - \frac{B^{e*}}{V^*}\right)\right] + \varepsilon_{R_L,t}^* \,, \tag{2.2.31}$$

for borrowing in domestic currency and

$$R_t^{L,*} = \varepsilon_{b,t}^* R_t^* \exp\left[\phi_{nw}^* \left(\frac{B_t^{e*}}{V_t^*} - \frac{B^{e*}}{V^*}\right)\right] + \varepsilon_{R_L,t}^* \,, \tag{2.2.32}$$

for borrowing in foreign currency. B_t^{e*} is the global entrepreneur nominal debt and $\varepsilon_{R_L,t}^*$ is a pure foreign credit supply shock.[27] V_t^* is the net worth defined as

$$V_t^* = P_t^{k*} \bar{K}_t^* \,, \tag{2.2.33}$$

where $\bar{K}_t^*$ is capital in the world economy and P_t^{k*} is its price. Foreign banks therefore introduce contagions from developments in the global market into the domestic economy through the interest rate $R_t^{L,f}$ they charge in the domestic economy. Indeed, when lending funds to domestic entrepreneurs, they change a premium over the domestic deposit rate function of global entrepreneurs balance sheets and foreign credit supply shocks.[28]

2.2.4 Public authorities

The public sector consists of a central bank and a fiscal authority.

Central bank The monetary authority is assumed to follow a simple Taylor-type rule

$$R_t = \rho_r R_{t-1} + (1-\rho_r)\left(R + \tau_\pi \pi_t^c + \tau_{\Delta y}\left(\frac{y_t - y_{t-1}}{y_{t-1}}\right) + \tau_{\Delta s}\left(\frac{S_t}{S_{t-1}}\right)\right) + \varepsilon_{R,t}, \tag{2.2.34}$$

where ρ_r is the interest rate smoothing parameter, τ_π is the response to current consumer price inflation, $\tau_{\Delta y}$ to (real) GDP growth deviation from its trend and $\tau_{\Delta s}$ to the change in exchange rate. The exogenous process $\varepsilon_{R,t}$ is a monetary policy shock. Similar Taylor Rules include Lubik and Schorfheide (2007) and Ortiz and Sturzenegger (2007), Hove et al. (2015), Alpanda et al. (2011), Liu et al. (2009) for models applied to South Africa. The estimated parameter on inflation for South Africa is also consistent with the adoption of inflation targeting which

[27] The global entrepreneurs' debt includes both domestic and foreign entrepreneurs. However by small open economy assumption domestic entrepreneurs are too small to have an impact on this ratio.

[28] The foreign credit supply shock is identified based on foreign variables: from equation (32), it is a shock that raises the spread between the lending and deposit rates for reasons unrelated to foreign entrepreneurs balance sheets.

formally started in February 2000.

Government The government collects taxes on consumption, labour and capital and follows a simple spending rule

$$g_t = \rho_g g_{t-1} + (1-\rho_g)\bar{g} + \varepsilon_{g,t}, \tag{2.2.35}$$

where $g_t = \frac{G_t}{z_t}$ and $\bar{g}$ is the steady-state stationary value of government spendings and $\varepsilon_{g,t}$ is a government spending shock. We assume that government consumption is composed of domestic goods only.

2.2.5 Closing market conditions

In equilibrium the final goods market, the loan market and the foreign bond market have to clear. The final goods market is in equilibrium when the demand from domestic households, the government and foreign households equal the domestic supply of final good. The aggregate resource constraint has thus to satisfy the following condition on the use of the domestic good:

$$C_t^d + I_t^d + G_t + (1-\omega_x)X_t^f \leq Y_t^f - a(u_t^p)\overline{K}_t^p - a(u_t^f)\overline{K}_t^f. \tag{2.2.36}$$

In the same way we define the idendity on GDP by

$$Y_t = C_t + I_t + G_t + X_t - M_t \ , \tag{2.2.37}$$

where $I_t = I_t^p + I_t^f$, $X_t = X_t^f + X_t^p$ and $M_t = C_t^m + I_t^m + N_t^m + \omega_x X_t$.

The loan market clears when the demand for liquidity from the firms and entrepreneurs equals the supply of liquidity including savers' deposits and monetary injection by the central bank. Since the Central Bank liquidity supply is perfectly inelastic at its policy rate we can abstract from defining money supply.

Finally, the foreign asset market clears when the positions of the exporting and importing firms equal the households' choice of foreign bond holdings. Foreign assets evolve according to:

$$\begin{aligned} S_t B_{t+1}^* &= R_{t-1}^* \Phi\left(a_{t-1}, \tilde{\phi}_{t-1}^a\right) S_t B_t^* + S_t P_t^x X_t^f + S_t P_t^{*c} X_t^p \\ &- P_t^m \left(C_t^m + I_t^m + N_t^m + \omega_x (X_t^f + X_t^p)\right). \end{aligned} \tag{2.2.38}$$

2.3 Empirical strategy

We start by summarizing the driving forces in our model. Thereafter, we present the data and estimation technique used for a number of parameters. Finally, we discuss the calibration of remaining parameters.

2.3.1 Structural shocks

Table 2.1 summarizes the innovations analyzed in the paper. We define three broad categories of structural shocks: domestic, foreign, and SOE shocks. Domestic and foreign shocks are disturbances that are unambiguously identified from domestic and foreign origins, respectively. SOE shocks, on the other hand, are disturbances that may have both domestic and foreign origins. Our primary interest is to understand the role of foreign shocks in South Africa.

Domestic and foreign shocks are classified in five groups: real aggregate demand shocks (AD) including wedge shocks[29], investment specific shocks, and government consumption shocks; aggregate supply shocks (AS) including productivity shocks, cost-push shocks and wage push shocks; monetary policy shocks (MP); credit supply shocks (Cred); and commodity supply shocks (Com).

In this paper we analyze three SOE shocks: export demand shocks, import demand shocks, and the country risk premium shock. SOE shocks might be caused by internal as well as external factors. For example, export demand shocks could be driven by internal factors such as changes in domestic export policies or changes in the quality of domestic products. In the same way export demand shocks could be explained by external factors such as changes in foreign taste for domestic goods or shocks originating from the rest of the world but outside the G7 countries. Symmetric arguments hold true for import share shocks. The country risk premium could also be explained by changes in domestic country risk (beyond what is captured by the net foreign asset position) or by a change in foreign risk aversion leading to a revision of the price of exchange rate risks. Given the lack of a clear-cut identification of the origins of these shocks, we label them as SOE shocks in our baseline analysis. Note also that these SOE shocks are restricted not to impact on foreign variables.

2.3.2 Data and estimation

We estimate the model using quarterly data on 13 domestic and 9 foreign variables over the period 1994Q1 to 2016Q1. The start date is to avoid the apartheid period in South Africa (which was characterized by instability and relatively low trade linkages with the rest of the

[29]Wedge shocks could also be interpreted as financial shocks and as a result they could be grouped together with credit supply shocks. However, considering that their main impact is on consumption and investment, we decided to label it as a real demand shock.

Table 2.1: Overview of structural shocks

	Symbol	Process	Group	Description
Foreign shocks				
Wedge	$\varepsilon^*_{b,t}$	AR(1)	AD*	Wedge between the monetary policy rate and the return on asset held by households and affecting consumption and investment
Investment specific	Υ^*_t	AR(1)	AD*	Investment efficiency shock
Government demand	$\varepsilon^*_{g,t}$	AR(1)	AD*	Government consumption shock
Mark-up	$\lambda^*_{d,t}$	AR(1)	AS*	Distributors mark-up shock
Wage-push	$\lambda^*_{w,t}$	AR(1)	AS*	Wage mark-up shock
Productivity	$\varepsilon^*_{k,t}$	AR(1)	AS*	Capital specific productivity shock
Monetary policy	$\varepsilon^*_{R,t}$	AR(1)	MP*	Deviation from Taylor Rule
Credit supply	$\varepsilon^*_{R_L,t}$	AR(1)	Cred*	External financing premium (spread) shock
Commodity supply	$\varepsilon^*_{L,t}$	IID	Com*	Land stock shock in primary sector
SOE shocks				
Export demand	$\varepsilon_{x,t}$	ARMA(1,1)	Trade	Shocks to export share in the foreign economy
Import demand	$\varepsilon_{x,t}$, $\varepsilon_{m,t}$	ARMA(1,1)	Trade	Socks to import share and correlated with export shocks
Import mark-up	$\lambda_{m,t}$	AR(1)	Trade	Importing distributors mark-up shock
Country risk premium	$\tilde{\phi}_t$	AR(1)	UIP	Country risk premium shock (affecting UIP condition)
Domestic shocks				
Wedge	$\varepsilon_{b,t}$	AR(1)	AD	Wedge between policy and monetary policy rate and the return on asset held by households and affecting consumption and investment
Investment specific	Υ_t	AR(1)	AD	Investment efficiency shock (in primary and secondary sectors)
Government demand	$\varepsilon_{g,t}$	AR(1)	AD	Government consumption shock
Mark-up	$\lambda_{d,t}$	AR(1)	AS	Domestic distributors mark-up shock
Wage-push	$\lambda_{w,t}$	AR(1)	AS	Wage mark-up shock (note: not used in the baseline estimation)
Productivity	$\varepsilon_{k,t}$	AR(1)	AS	Capital specific productivity shock in primary and secondary sectors
Monetary policy	$\varepsilon_{R,t}$	IID	MP	Deviation from Taylor Rule
Credit supply	$\varepsilon_{R_L,t}$	AR(1)	Cred	External financing premium (spread) shock
Commodity supply	$\varepsilon_{L,t}$	IID	Com	Land stock shock in primary sector

world). We also experiment with estimating the model with different sample periods but our main empirical results remain qualitatively unchanged. For instance, we end the sample period in 2010Q1 in order to isolate the zero lower bound period facing advanced countries. In the same way we start the sample period in 2000Q1, which corresponds to date when inflation targeting was formerly introduced in South Africa.

The following domestic variables are used: GDP; consumption; investment; total imports; total and commodity exports; employment; consumer and import price indexes; wages (not included in the baseline); risk free rate; interest rate spread; and nominal effective exchange rate. The spread is proxied using the default rate. We also tested the difference between 10 years yield on EKSOM and the government. Commodity exports are proxied by sales in the mining sector (about 70% is exported). As just mentioned, we use employment as observed variable. However, in the model, there is no unemployment, only hours worked. We therefore follow Adolfson et al. (2007) and introduce an ad hoc equation linking employment to hours with a labour hoarding parameter described in the appendix. We allow for measurement errors (whose variance are calibrated to reasonably small values). Foreign variables include GDP; consumption; investment; consumer price index; wages; risk free rate; spread; hours worked and commodity price. We used US data in the baseline estimation and G7 data as a robustness check. We used G7 data computed directly by the OECD as well as the principal component of each series and the results were very close. Commodity prices are measured as an average of world coal, platinum, silver, gold and aluminium prices. It includes important South African commodities. The foreign spread is measured as the difference between BBB and 10 year government bonds.

We estimate the model with Bayesian methods (e.g. DeJong et al. (2000), Otrok (2001) and Schorfheide (2000)). In the baseline analysis, we estimate the model in two steps. First, foreign parameters are estimated using only data from the foreign economy. Second, domestic parameters are estimated on the full dataset, calibrating foreign parameters at their mode values. In a robustness exercise, we estimate domestic and foreign parameters in one step and our main results remain qualitatively unchanged.

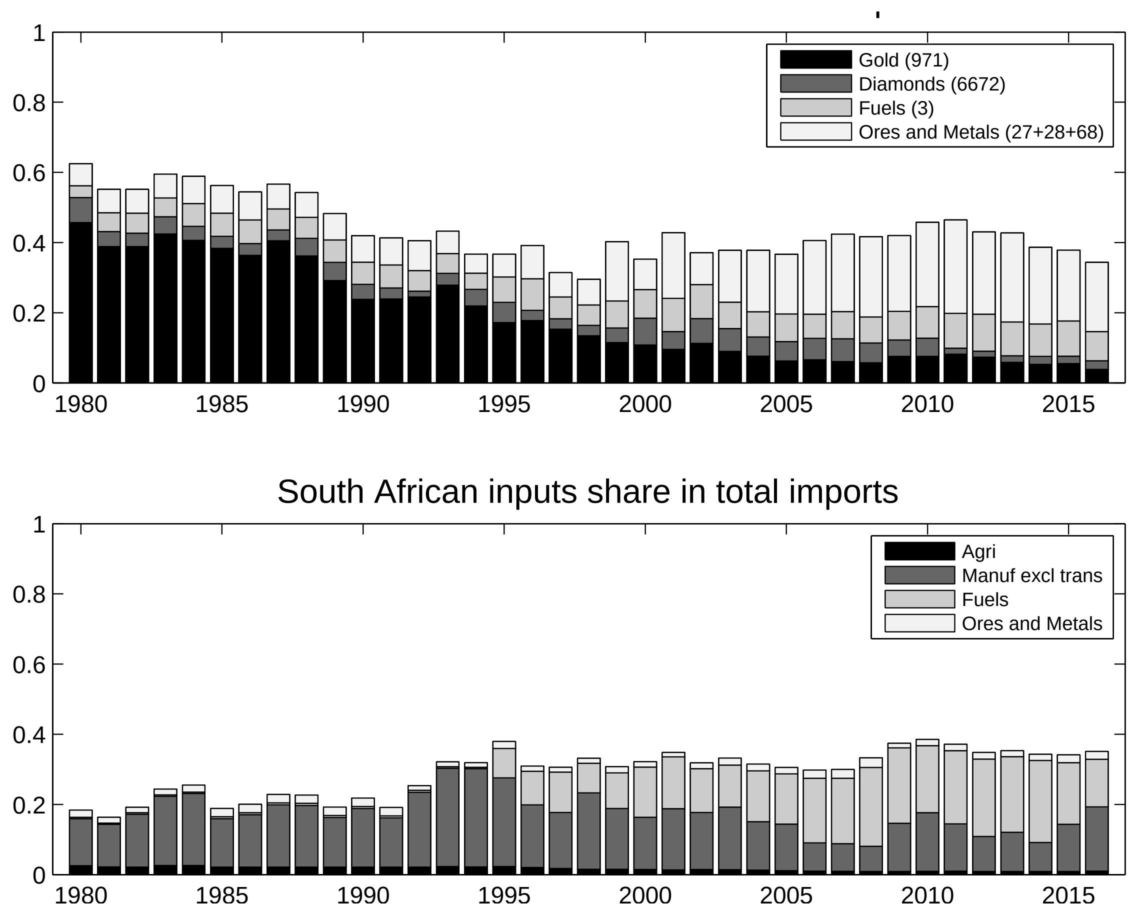
2.3.3 Calibration

The values of calibrated parameters are given in Table 2.6 at the end of the paper. We briefly discuss a number of important calibrated parameters in this section. For more details, we refer to appendix D.

Households The share of rule of thumb households (which are excluded from financial markets) is equal to 1/3. This number is consistent with the data that only about 70% of adults (aged 15 and above) have an account in South Africa (World bank financial inclusion database, 2014). The share of entrepreneurs is set to 1/3 as in Gerali et al. (2010). The discount factor of savers β_S and entrepreneurs β_E are fixed in order to match the average risk-free interest rate and spread, respectively.

Imports Using data from OECD on the import content of exports, we calibrate ω_x to 0.2. We fix the remaining shares of imports in household consumption ω_c, investment ω_i, and domestic production ω_n, based on the methodology proposed by Kose (2002) and the calibration proposed by du Plessis et al. (2014) on South Africa. Following Kose (2002), we find that the input share fluctuated between 40 and 50% over the estimation period. Considering the broad input categories presented in Equation (2.2.22) and the import content of exports, calibrating ω_n to 0.1 implies that together, those inputs account for about 50% of South African imports. We further calibrate ω_c and ω_i to 0.1 and 0.33, respectively (du Plessis et al. (2014) also assign a larger share of imports in the investment than in the consumption basket). All together those values imply an import to GDP ratio of about 28% as observed in the data.

Figure 2.1: Inputs import and commodities export shares



Mining sector Mining exports to GDP ratio is set to 10%, which implies that mining represents about 36% of total exports. Figure 2.1 shows the evolution of South African commodity exports. The data indicates that the share of mining export decreased from well above 50% in the 1980s to between 30% and 45% over the estimation period (1994-2016). Moreover, it can be observed that the overall decrease in the share of commodity exports was caused by a large drop in gold (but partially compensated by an increase in fuels and ores and metals exports). We follow again Kose (2002) and fix the capital share in the mining sector α_p to 0.18. The land share β_p is calibrated to ensure that households devote 6.7% of their labour efforts to the mining sector on average. This value corresponds to the mining sector's share in total non-agricultural employment reported by the South African Chamber of Mines. The elasticity of substitution between production factors in the mining sector σ_p is set to 1/3.

Financial sector The fraction of firms' wage bill and inputs v_n financed in advance is set to 1. Entrepreneurs debt ensures that the credit provided to the private sector to GDP ratio averages to 150%.[30] The share of foreign banks in domestic credit is calibrated to 22% (Claessens and Horen (2014) estimate the share of foreign banks assets among total banks assets to 22%). The share of foreign assets in domestic banks balance sheets is calibrated to 6.6%.[31]

Foreign economy Capital and commodity income shares are calibrated to 0.25 and 0.05, respectively. Entrepreneurs credit to GDP ratio is set to 200%. For simplicity, most other calibrated parameters in the foreign economy are set at their domestic counterparts' values.

2.4 Empirical results

We begin by discussing the estimated parameter values. Subsequently, we use variance decomposition and historical decomposition to identify the driving forces of macroeconomic fluctuation in South Africa. Thereafter, we study the transmission mechanisms of the structural shocks and demonstrate the importance of commodity and financial channels in the transmission of foreign shocks. Finally, we undertake a number of robustness exercises.

2.4.1 Estimated parameters

Table 2.7 reports the parameter values (including the prior mean and standard deviation; as well as the estimated posterior mode and 90 % credible intervals) whereas Table 2.8 presents the AR coefficients and the standard deviation of the shocks processes. The prior and posterior distributions of all estimated parameters are presented in the appendix.

[30] Credit provided to the private sector to GDP ratio fluctuated between 100 and 160% over the estimation period, World Bank database.

[31] Bank foreign currency loans and advances to total assets ratio from SARB. We prefer this measure to the Claims on Non-Residents to domestic assets ratio from the IMF-IFS (17% over the 2001-2015 period).

In the foreign block, a key parameter of interest is the elasticity of substitution σ_d^* between commodity and other (labour and capital) inputs. We used a relatively flat prior due to limited information regarding this parameter in the literature. We estimate this parameter value to be low at 0.18, implying that commodity prices respond relatively strongly to foreign business cycles through firms demand. In the same way we estimate a low value for the spread elasticity to borrower net worth ratio (fixing its prior mean to 0.05; e.g. as in Bernanke et al. (1999)) to about 0.02. The land depreciation rate (which generates an hump-share response of commodity price to commodity supply shocks) is estimated to 0.04, which implies relatively high persistence in the commodity supply shock. Other parameter are estimated to values which are fairly standard in the literature.

For the domestic block, we estimate the spread elasticity to borrower net worth ratio much lower value of 0.015, suggesting that the financial accelerator is relatively modest in this economy.

We assume that domestic elasticities of substitution of consumption and investment are identical ($\eta_c = \eta_i$) due to the lack of information (we do not have data on the composition of imports). The domestic η_c and foreign η_f elasticities are estimated to be small (about 0.5 and 0.7 respectively). We also note that investment adjustment cost is large (between 6 and 8.3 depending on the specifications) and that variable capital utilization is estimated to be irrelevant.

Finally, the estimated values of the monetary policy rule suggest that the South African Reserve Bank (SARB) has responded more aggressively to inflation (1.75). This result is consistent with the inflation targeting regime. A useful next step will be to investigate the extend to which the central bank respond to export and import price inflation. The coefficients on the change in the NEER and the growth rate of GDP are 0.11 and 0.5, respectively. These findings suggest that authorities at SARB are primary concerned with inflation stabilization but they do not neglect completely fluctuations in real activity and the exchange rate.

2.4.2 Variance decomposition

Variance decomposition is computed at the posterior mode for the baseline model.

Foreign shocks contribution to foreign variables Table 2.2 shows foreign shocks contribution to the variation of foreign variables (upper panel) and domestic variables (lower panel).[32] The most important drivers of economic fluctuations in US GDP are demand shocks (44% summing wedge, investment specific and public consumption shocks), followed by aggregate supply shocks (26% summing TFP, cost-push and wage-push shocks), monetary policy shocks

[32]Note that the sum of variances do not sum to 100 due to the inclusion of small calibrated measurement errors in the estimation.

(22%), credit supply shocks (6%) and commodity supply shocks (2%). The most important drivers of price fluctuations in the US are aggregate supply shocks. Both Aggregate demand and supply shocks have a large impact on the monetary policy rate. Business cycles shocks in the foreign bloc such as demand, supply, monetary policy and credit capture about 48% of fluctuations in commodity prices. Foreign credit shocks explain 90% of the variance in the spread reflecting the large spike in US spread data during the financial crisis.

Table 2.2: Foreign shocks contribution to foreign and domestic variables

	AD*	AS*	MP*	Com*	Cred*	All*
US GDP	43.69	26.14	22.05	1.74	5.68	99.30
US Consumption	42.09	28.60	24.53	1.01	3.06	99.29
US Investment	49.42	20.08	16.19	3.01	10.57	99.27
US Hours	43.47	27.24	21.90	1.16	5.60	99.37
US CPI	23.03	61.91	10.00	3.30	1.19	99.43
US Wage	19.32	65.74	11.15	1.81	1.32	99.34
US Risk-free rate	36.32	34.22	20.33	5.80	2.16	98.83
US Spread	3.20	2.05	0.72	3.02	90.37	99.36
Commodity Price	21.16	13.83	10.00	51.75	2.43	99.17
SA GDP	7.12	5.60	3.05	7.75	1.67	25.19
SA Employment	8.09	5.50	3.78	9.96	2.06	29.39
SA Consumption	2.13	8.26	3.48	15.90	1.10	30.87
SA Investment	1.21	11.29	3.19	20.97	0.97	37.63
SA Exports	7.45	2.05	0.95	3.04	0.69	14.18
SA Imports	0.66	4.71	1.69	5.20	0.36	12.62
SA Mining exports	6.51	3.21	1.92	9.30	0.75	21.69
SA CPI	6.62	5.19	1.09	6.92	0.67	20.49
SA MPI	1.04	16.75	2.40	6.90	0.02	27.11
SA Wage	7.12	3.88	1.37	14.39	1.05	27.81
SA Risk-free rate	9.38	3.51	0.90	11.39	1.05	26.23
SA Spread	7.72	2.25	1.04	13.67	6.73	31.41
SA NEER	0.27	5.04	9.62	9.59	0.10	24.62

Note: Risk-free rate and spread in levels; NEER in Q/Q growth rate; all other variables in Y/Y growth rates. Stars stand for foreign shocks. See Table 2.1 for a description of the shocks classification. The last column is the total contribution of all foreign shocks. US data in the upper panel, South African data in the lower panel.

Foreign shocks contribution to domestic variables The lower panel of Table 2.2 reports foreign shocks contribution to macroeconomic fluctuation in South Africa. The data confirms the finding obtained with SVAR analysis that that foreign shocks are important drivers of economic fluctuations in South Africa (e.g. Houssa et al. (2015)). Together, foreign shocks explain between 20% and 38% of the fluctuations in South African macroeconomic variables over the 1994 to 2016 period (with the notable exception of imports and exports at 13% and 14%, respectively). They account for a large share of fluctuations in GDP (25%), CPI (20%), risk-free rate (26%) and exchange rate (25%). The larger shares are observed for investment (38%), consumption (31%), and the spread (31%).

Going through specific foreign shocks, we can see that commodity supply shocks play a dominant role: they explain 8% of the fluctuations in GDP; 16% for consumption; 21% for investment; 9% for mining exports; and 14% for the spread. Besides, foreign (demand, monetary, credit supply, and supply) explain about 50% of variation in commodity price. Altogether, these findings are line with the view that commodity prices have a large impact on commodity exporting countries and that these shocks generate excess volatility in consumption and investment.

Foreign aggregate demand shocks have a large impact on exports (7%), interest rates (9%) and GDP (7%). Foreign supply shocks have a notable impact on consumption (8%) and investment (11%) through their impact on the import price index (17%). Foreign monetary policy shocks are important for the exchange rate (10%). Foreign credit supply shocks impact is modest. They explain 2% of fluctuations in output (and 5% for the spread) which reflects the relatively low exposure of South African banks to the global economy.

Table 2.3: Domestic and SOE shocks contribution to domestic observed variables

	Trade	UIP	SOE	AD	AS	MP	Com	Cred	Domestic
GDP	20.72	4.18	24.90	18.27	12.82	5.30	11.36	1.66	49.41
Employment	13.62	2.65	16.27	17.00	28.20	5.50	1.34	1.85	53.89
Consumption	9.90	2.33	12.23	28.90	17.24	6.68	1.12	2.27	56.21
Investment	5.50	3.20	8.70	48.61	1.76	0.95	0.07	1.44	52.83
Exports	54.29	6.59	60.88	2.19	1.37	0.37	20.18	0.02	24.13
Imports	76.20	1.28	77.48	6.49	0.64	0.39	1.15	0.30	8.97
Mining exports	0.33	4.25	4.58	0.41	1.85	0.31	66.05	0.03	68.65
CPI	15.56	10.97	26.53	25.01	22.70	4.17	0.08	0.20	52.16
MPI	49.60	16.47	66.07	4.70	0.22	0.87	0.01	0.02	5.82
Wage	9.68	4.43	14.11	23.92	26.82	3.64	0.31	0.23	54.92
Risk-free rate	7.16	13.14	20.30	40.13	6.21	5.22	0.29	0.14	51.99
Spread	1.48	3.39	4.87	7.61	0.80	0.26	0.08	54.22	62.97
NEER	0.90	67.57	68.47	3.03	0.32	2.52	0.06	0.00	5.93

Note: Risk-free rate and spread in levels; NEER in Q/Q growth rate; all other variables in Y/Y growth rates. See Table 2.1 for a description of the shocks classification. The third column is the total contribution of all SOE shocks. The last column is the total contribution of all domestic shocks.

SOE shocks Table 2.3 reports the variance decomposition for domestic and SOE shocks. [33] The data show that SOE shocks matter for a number of key macroeconomic variables in South Africa (such as the exchange rate, trade volume, GDP, and import prices). In particular,

[33] Remember that SOE cannot affect foreign variables.

these shocks explain about 68% of the fluctuations in the exchange rate (compared to 88% for the UIP shock alone in Alpanda et al. (2010)). They also explain the vast majority of the fluctuations in imports (77%) and exports (61%). Data on exports and imports are very volatile and correlated. Trade shocks, which include correlated export and import shocks, can replicate this large volatility without having dramatic impact on other variables and are therefore given a large weight in the estimation. Although foreign demand shocks also have an economically important impact on exports, they are unable to explain the bulk of large fluctuations in this variable.

Domestic shocks Domestic shocks remain important drivers of economic fluctuations (see Table 2.3). Pure domestic shocks explain about 50% of fluctuations in GDP, CPI and risk-free rates. They are particularly important for the fluctuations in consumption (56%), spread (63%) and mining exports (69% with most of the fluctuations in mining output explained by domestic commodity supply shocks). Domestic shocks also only offer weak explanation for the fluctuations in imports (9%), exports (24%) and exchange rate (6%).

2.4.3 Historical decomposition

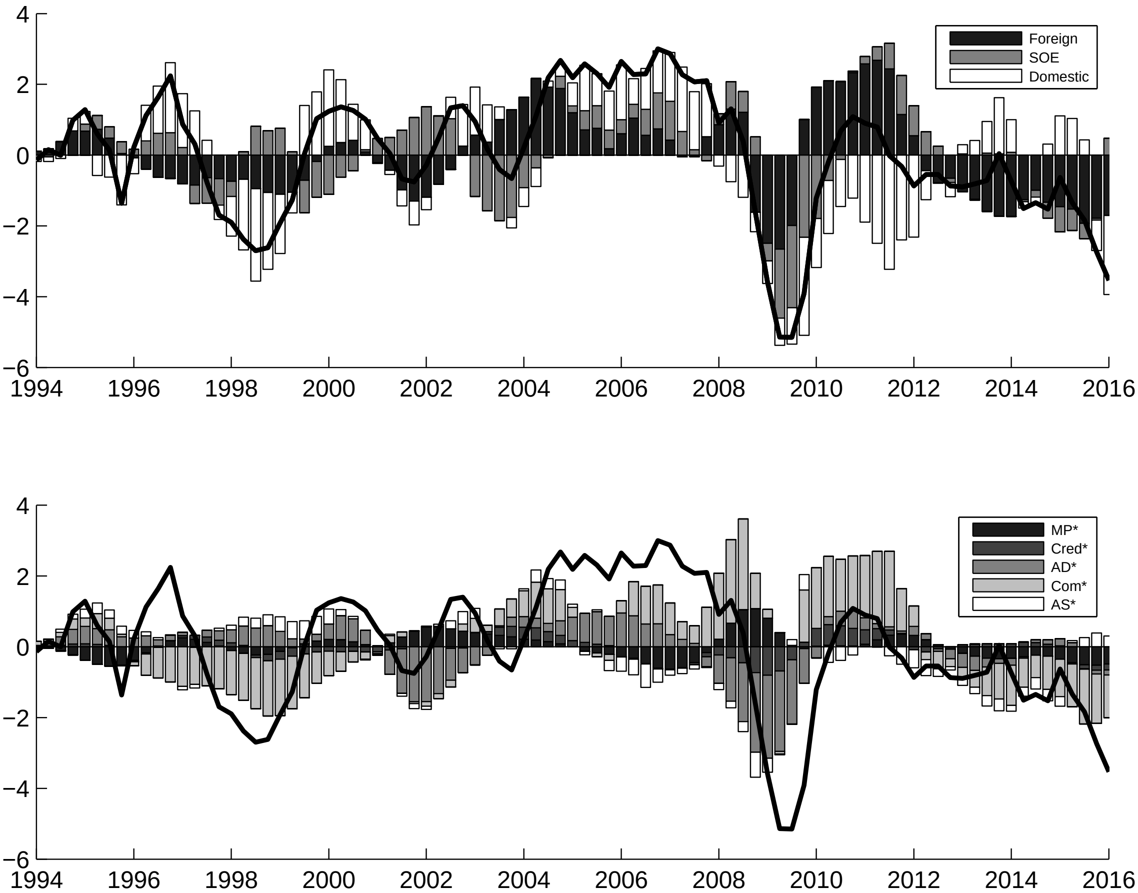
Historical Decomposition is employed to study the role the structural shocks have played during key historical episodes such as the Rand crises in 1996, 1998 and 2001; the 2004-2007 growth period; the 2007/08 global financial crisis; and the commodity price collapse of 2015. Figures 2.2-2.5 display the historical decomposition for world commodity price and three macroeconomic series for South Africa: GDP, export volume, and the NEER. The upper panel in each figure highlights the contributions of domestic, foreign, and SOE shocks whereas in the lower panel we present a disparaging analysis across foreign shocks.

Adverse commodity prices shocks of the late 1990s (that coincided with the Asian financial crisis of 1997) had a major impact during the 1998 South African Rand crisis. The SARB responded to the Rand depreciation by tightening its monetary policy where the policy rate increased by almost 700 basis points in half year time. This drastic interest rate increase is another (domestic) factor that contributed to amplifying the crisis. It is interesting to compare this crisis to two other Rand crises that South Africa experienced in 1996 and 2001. The former occurred following US monetary policy tightening in 1994/95 whereas the later happened after the burst of the dot-com bubble in 2000, which translated into a negative contribution of foreign demand shocks in 2001/02. However, none of these two Rand crises where accompanied with large changes in domestic policy rates nor on commodity prices and their impacts on the South African GDP were modest.

Is it also interesting to see other historical events. For instance, the data in Figure 2.2 show that commodity supply and strong foreign demand as well as SOE shocks contributed to

Figure 2.2: Historical Decomposition: South African GDP

Upper Panel: Total contribution of structural shocks to SA GDP YoY growth rate (re-centered around zero). Lower Panel: Selected foreign shocks (Monetary Policy, Credit, Commodity Supply and Aggregate Demand) contribution to SA GDP



2005-2007 sustained growth in South Africa. The 2007/2008 and the great recession episodes translated into the largest drop in South African GDP growth via adverse foreign aggregate demand and credit shocks and their associated effects on commodity demand. Negative foreign aggregate supply and SOE shocks also contributed (to a lower extend) to the recession in South Africa. Finally, positive commodity supply shocks (together with positive credit supply shocks that might be capturing the impact of Quantitative Easing) contributed to the 2011 recovery before the recent commodity price reversal (with the contribution of foreign commodity supply shocks reaching a through in 2015). The contribution of foreign monetary policy, which have been accommodative during the crisis, later turned into negative effects at the end of the estimation period.

Figure 2.3: Historical Decomposition: South African Export Volume

Upper Panel: Total contribution of structural shocks to SA Export Volume YoY growth rate (re-centered around zero). Lower Panel: Selected foreign shocks (Monetary Policy, Credit, Commodity Supply and Aggregate Demand) contribution to SA Export Volume

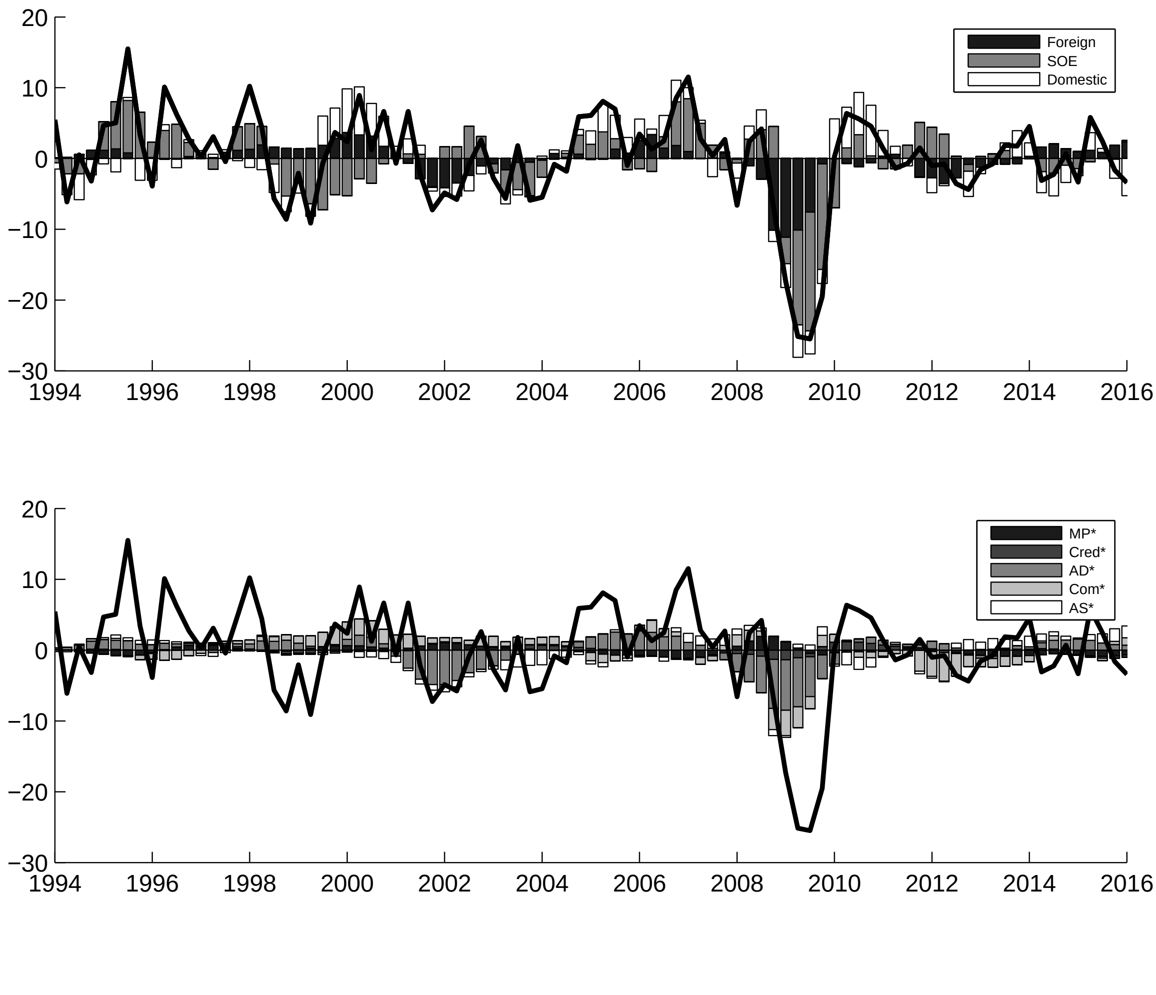


Figure 2.4: Historical Decomposition: South African NEER

Upper Panel: Total contribution of structural shocks to SA NEER YoY growth rate (re-centered around zero). Lower Panel: Selected foreign shocks (Monetary Policy, Credit, Commodity Supply and Aggregate Demand) contribution to SA NEER

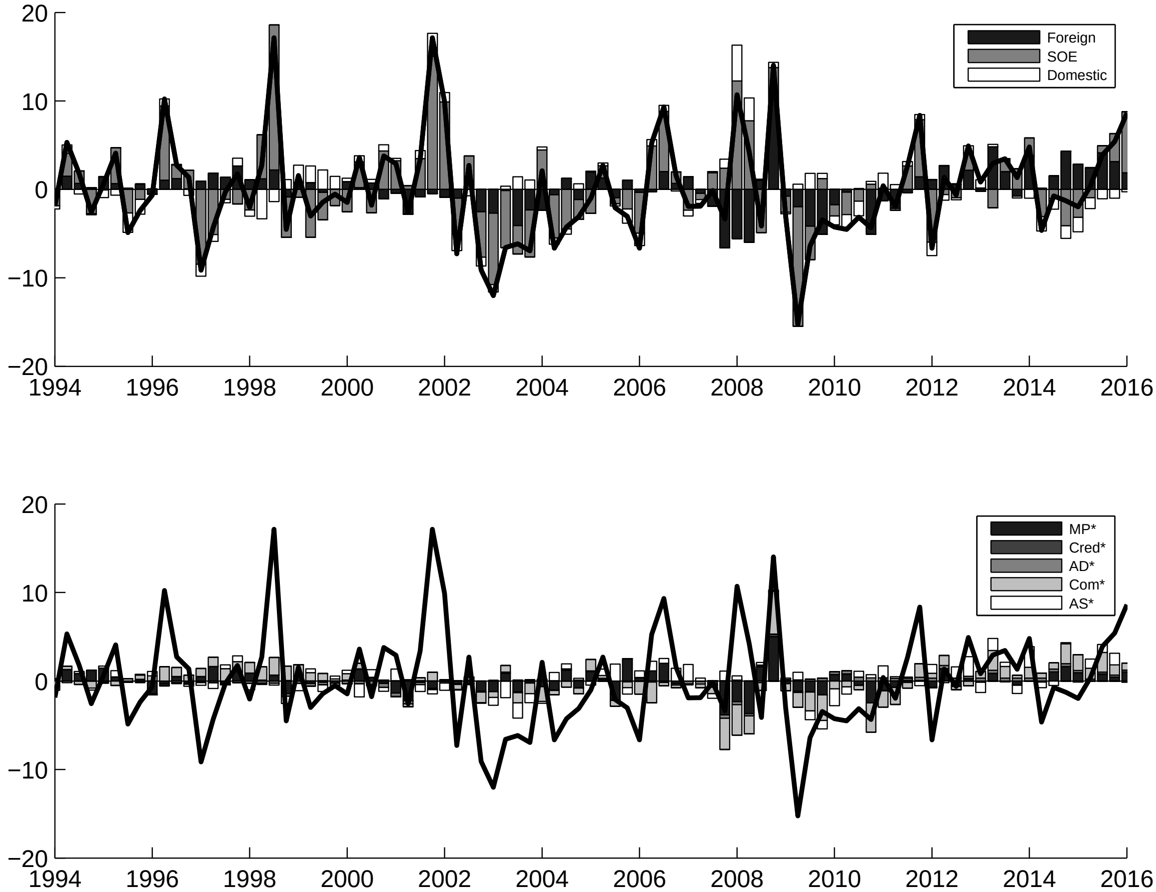
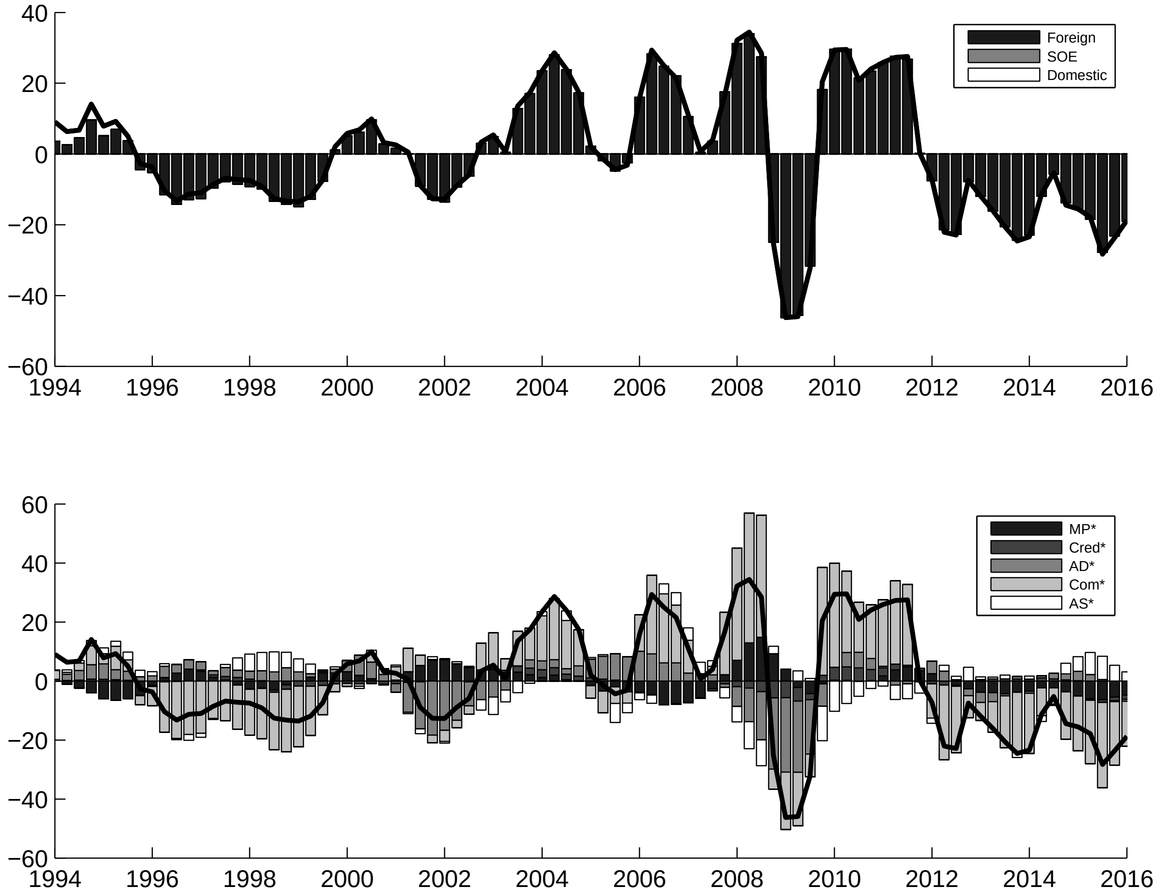


Figure 2.5: Historical Decomposition: Real world commodity price for mining

Upper Panel: Total contribution of structural shocks to world commodity price YoY growth rate (re-centered around zero). Lower Panel: Selected foreign shocks (Monetary Policy, Credit, Commodity Supply and Aggregate Demand) world commodity price

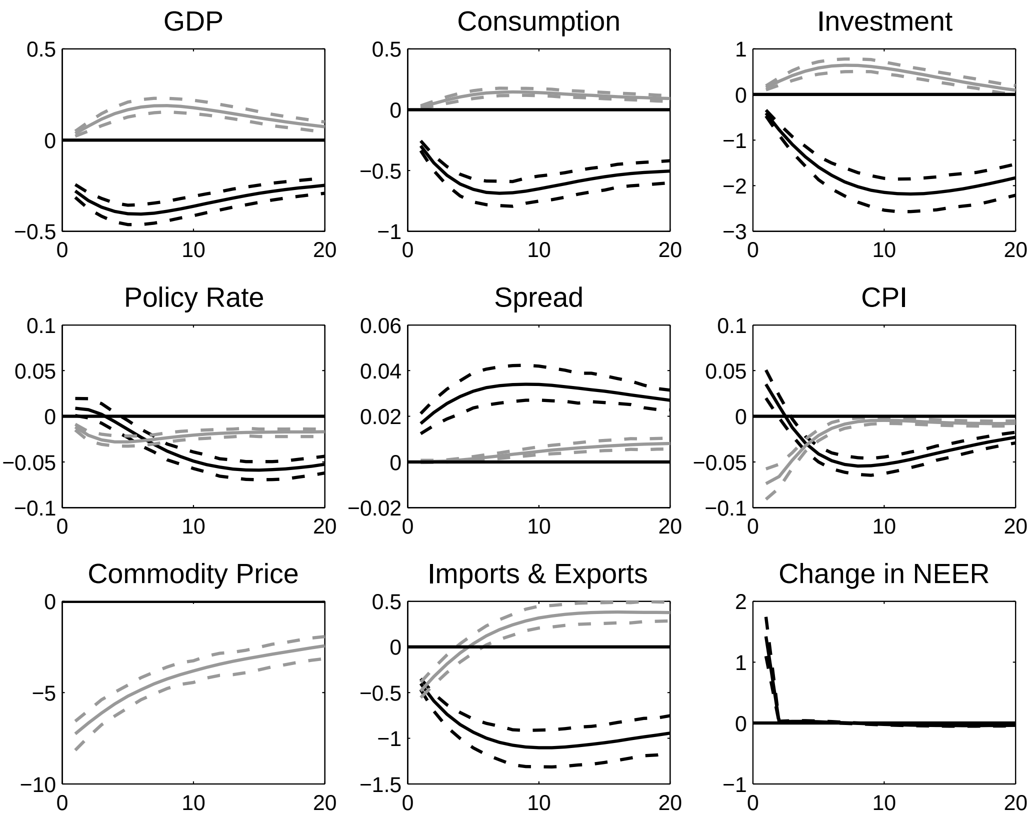


2.4.4 Shocks transmission

This section analyses the IRFs to foreign shocks. Its main message is that typical foreign business cycle shocks (such as aggregate demand, supply, credit and monetary policy) generate a positive co-movement between real activities in South Africa and USA. Foreign commodity supply shocks, on the contrary, provoke a negative co-movement between business cycles of these two economies. In what follows, we detail on each foreign shock one at a time. Analysis on SOE and domestic shocks is presented in the appendix.

Figure 2.6: IRFs - Foreign Commodity supply shock

Note: Variables expressed in percentage deviation from steady-state, inflation and interest rates annualized. Horizon in quarters. Baseline model with SA variables in black (except exports in grey) and US variables in grey and 90% confidence bands.



Commodity supply Figure 2.6 shows the IRFs of domestic (in black) and foreign (in blue) variables to a foreign commodity supply shock. This shock is modelled as an exogenous increase in global commodity production. It lowers their relative prices and act as a positive supply shock in the foreign economy by reducing firms marginal costs. Foreign prices decreases and output expands in the final good sector. The central bank responds by easing its monetary policy and banks tight their credit conditions (because the higher credit demand dominates the increase in collateral value).

The contraction in mining prices causes a drop in mining production. Revenues from mining activities collapse, damaging the trade balance (in nominal term) and leading to a build up of foreign debt. This increases the risk associated to the domestic currency. In addition, anticipations of lower output and inflation rates (from lower aggregate demand) resulting in lower domestic interest rates further plays against the domestic currency. The exchange rate surges. Lower exports revenues and higher import prices depress imports, consumption and investment. Banks react to the worsening of borrowers collateral value by increasing the spread which further exacerbates the impact of the shock. On impact, aggregate export volumes suffer from the drop in commodity trade. However, the depreciation encourages final good sales abroad and aggregate exports turn positive after about one year.

Commodity price shock is a good candidate to explain the excess volatility in consumption (relative to output) as well as the large fluctuation in investment.[34] Indeed, the magnitude of the drop in consumption exceed the decrease in output and the magnitude of the drop in investment is large. This is explained by the depreciation of the Rand: a large share of the decrease in domestic absorption translates to a decrease in the demand for foreign consumption and investment goods.

Foreign aggregate demand Figure 2.7 shows the IRF of foreign and domestic variables to foreign wedge shocks.[35] In line with intuition a positive foreign demand shock stimulates real activity and prices in the US economy. As a result, the central bank responds by increasing its policy rate. This shock also increases demand for commodities whose prices surge. The spread decreases since the borrower net worth improves but latter increases due to a higher leverage ratio (driven by a sustained increase in consumption and investment).

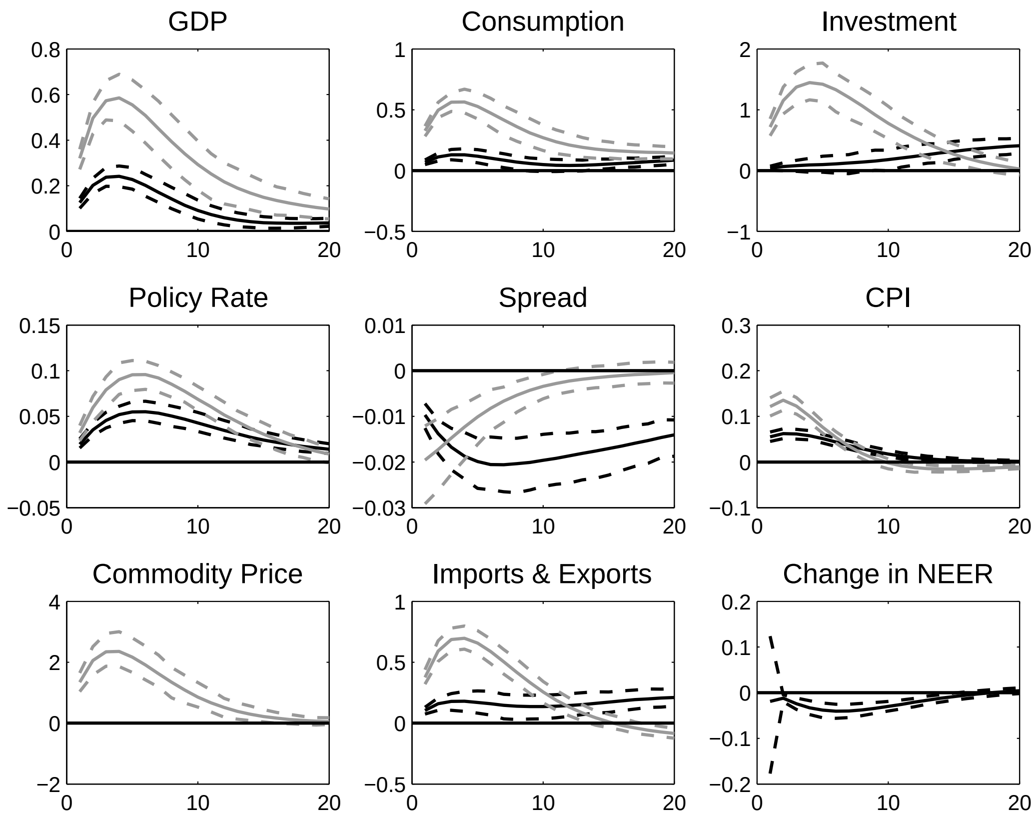
This surge in foreign demand and the associated commodity price increase stimulate domestic mining and manufacturing exports and as a consequence real activity and consumer prices rise in South Africa. The import content of exports generates a small positive co-movement between exports and imports. The rise in activity and mining prices have a positive impact on borrowers net worth which generates a drop in the spread. The central bank reacts by tightening its monetary policy stance in order to stabilize output and inflation. The responses of consumption and investment are initially moderate. The rise in economic activity generates more labour incomes, which rule of thumbs households spend immediately. However, optimizing households are encouraged to save by higher interest rates and delay consumption and investment plans.

[34]For a description of business cycles stylised facts in emerging economies, see Neumeyer and Perri (2005), Aguiar and Gopinath (2007) and Garcia-Cicco et al. (2010).

[35]Foreign demand shocks also include investment specific and public consumption demand shocks, which are presented in the appendix of the paper.

Figure 2.7: IRFs - Foreign demand shock (wedge shock)

Note: Variables expressed in percentage deviation from steady-state, inflation and interest rates annualised. Horizon in quarters. Baseline model with SA variables in black (except exports in grey) and US variables in grey and 90% confidence bands.



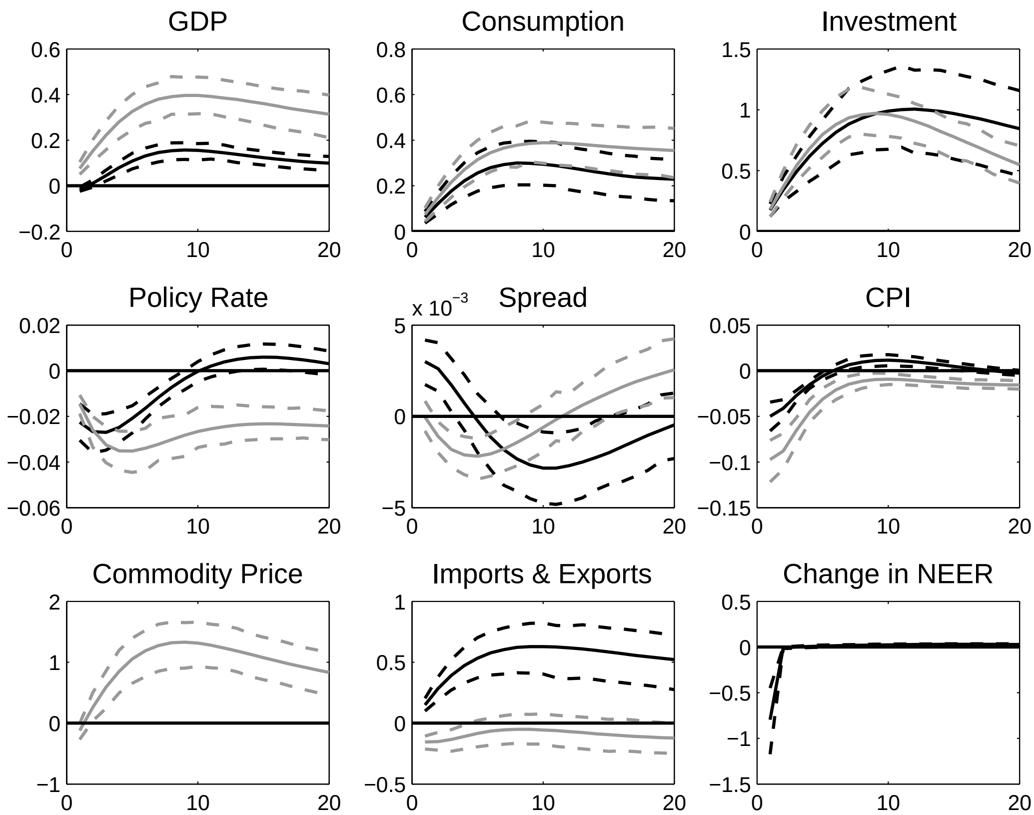
Foreign aggregate supply Figure 2.8 shows the IRF of foreign and domestic variables to an increase in foreign TFP. [36] Foreign supply increases leading to the traditional drop in prices and rise in GDP. Given the higher weight on inflation the central bank decreases its interest rate in order to stabilize this variable. Additional production progressively increases the need for commodity inputs which increases their prices. Higher capital prices and investment boost the collateral value of the firm and lead to a drop in the spread.

Foreign favourable supply shocks reduce foreign import prices and provoke an appreciation of the rand originating in the decrease in foreign interest rates. Households imported consumption and investment increase. The drop in import price also generates an initial decline in domestic CPI which in turn leads to an initial decrease in the risk free rate. The appreciation of the Rand depresses exports. However, the increase in investment and consumption demand also favours domestic firms. This later effect occurs since the elasticity of substitution between

[36]Foreign supply shocks also include cost-push and wage-push shocks, which are presented in the appendix of the paper.

Figure 2.8: IRFs - Foreign supply shock (TFP shock)

Note: Variables expressed in percentage deviation from steady-state, inflation and interest rates annualised. Horizon in quarters. Baseline model with SA variables in black (except exports in grey) and US variables in grey and 90% confidence bands.



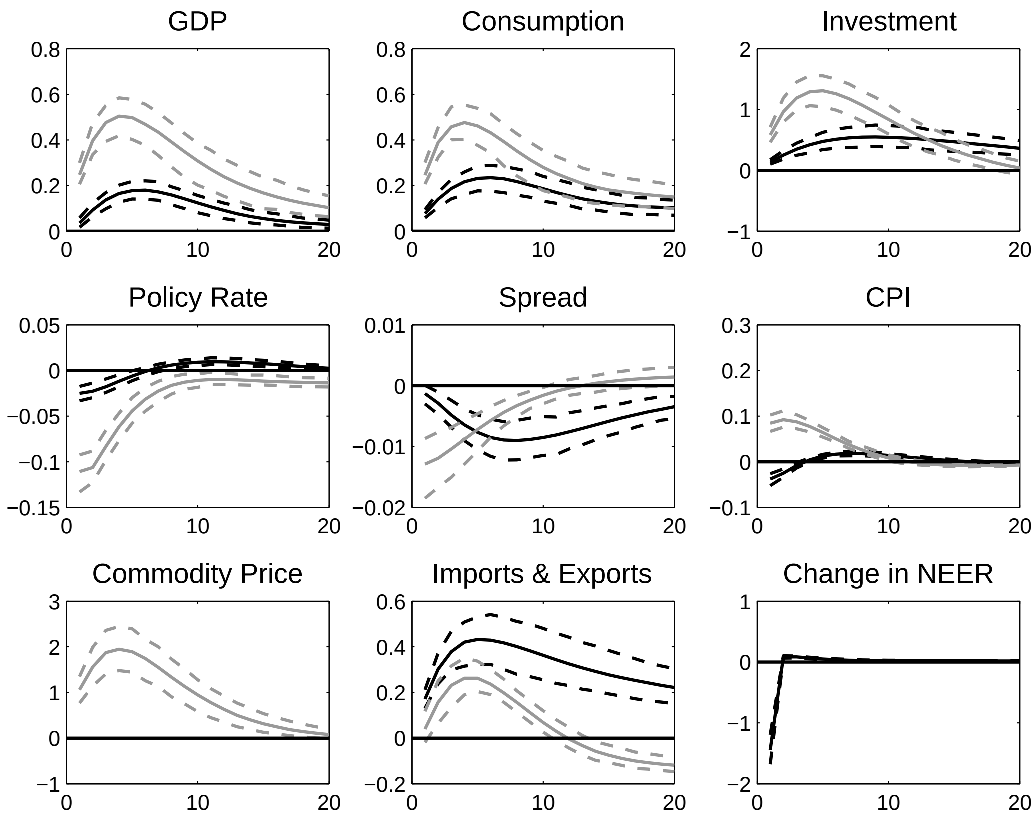
domestic and imported consumption and investment inputs is low. Therefore, the increase in imports also generate an increase in demand for domestic inputs by domestic households. After a few period, CPI-inflation turns positive, driven by the expansion in aggregate demand.

Foreign monetary policy Figure 2.9 shows the IRF to a foreign monetary policy shock. After an unexpected cut in the foreign policy rate, foreign GDP and inflation increase. This boosts the collateral value of the firms and incites banks to ease credit conditions. The real mining price follows the surge in global demand.

The contraction in foreign risk free rates provokes a strong appreciation of the rand which stimulates imports and decreases domestic prices on impact. The SARB responds by lowering its policy rate. Together with cheaper foreign inputs, this ease in domestic monetary policy stimulate consumption and investment. Exports also respond favourably to this shock benefiting from higher mining price and foreign demand (but mitigated by the strong appreciation). Higher collateral value and the ease in foreign credit conditions lead to a drop in the domestic

Figure 2.9: IRFs - Foreign monetary policy shock

Note: Variables expressed in percentage deviation from steady-state, inflation and interest rates annualised. Horizon in quarters. Baseline model with SA variables in black (except exports in grey) and US variables in grey and 90% confidence bands.



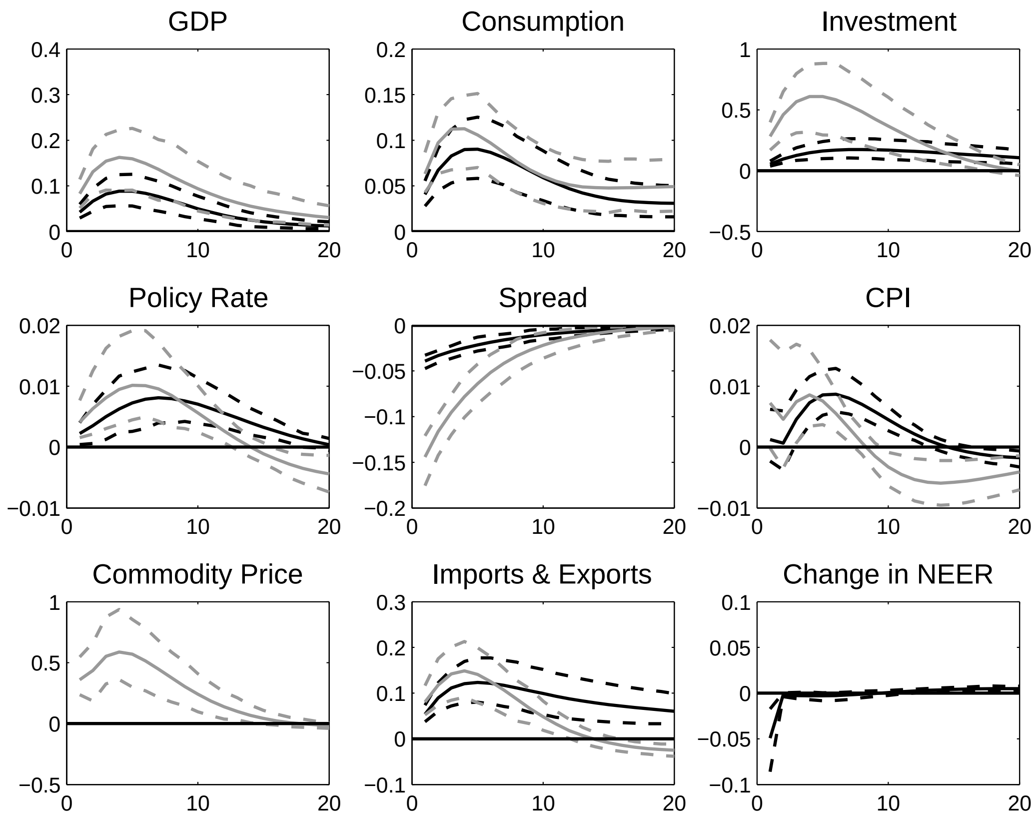
spread which further amplifies this boom. After a few periods, aggregate demand peaks which results in a rise in consumer price inflation rate and in a tightening of monetary policy.

Foreign credit supply Figure 2.10 shows the IRF of foreign and domestic variables to a foreign credit supply shock. This shock is simulated through an exogenous (and therefore unrelated to collateral) decrease in the risk premium. It causes a decrease in firms marginal production costs as well as an increase in consumption and investment demand from entrepreneurs. As a result, GDP increases while inflation and risk-free rates slightly increase (the demand effect dominates). The upswing in foreign production leads to an increase in demand for commodities that is transmitted to commodity prices.

Foreign banks operating in the domestic economy decrease the spread applied to South African firms and households. This ease in credit conditions causes a rise in domestic consumption and investment demands. The boom in the foreign economy increases foreign demand and therefore exports increase and the Rand appreciates. The appreciation of the rand stimulates

Figure 2.10: IRFs - Foreign credit supply shock

Note: Variables expressed in percentage deviation from steady-state, inflation and interest rates annualised. Horizon in quarters. Baseline model with SA variables in black (except exports in grey) and US variables in grey and 90% confidence bands.



imports and together with the drop in financing cost they translate into a moderate increase in consumer prices (these effects are dominated by the upward pressure on prices caused by the increase in domestic and foreign demands). The impact of this shock on domestic variables is similar to the foreign demand shock presented in Figure 2.7. This support the view that, due to the moderate direct exposure of South African banks on the foreign economy, adverse foreign credit supply shocks in 2007/08 were transmitted to the South Africa economy indirectly.

2.4.5 Transmission channels

We now investigate the relative importance of our different extensions to ALLV's model. We proceed in three steps.

Commodity, finance and imports First, we completely remove all of our extensions in the domestic economy (and estimate a model similar to Adolfson et al. (2007)[37] while leaving the foreign economy unchanged as in our baseline analysis presented in the previous sections). Looking at variance decomposition presented in Table 2.4, we can see that the contribution of foreign shocks to macroeconomic fluctuations in South Africa is low in this ALLV's model. For instance, the contribution of foreign shocks to the variability of GDP decreases sharply from 25 to 6%. Similar results hold true for other macroeconomic variables. This finding demonstrates that our extensions are necessary to capture the role of foreign shocks in South Africa. The difficulty of standard SOE models to account for the influence of foreign is well known in the literature (e.g. Justiniano and Preston (2010)).

Commodity sector Second, we only remove the domestic commodity sector from our baseline model and we re-estimate the model (while leaving the domestic export to GDP ratio and the foreign economy again unchanged as in our baseline analysis). Results are reported in Table 2.4. Closing the commodity channel generates a dramatic decrease in foreign shocks contribution to domestic real variables such as GDP (25% to 9%). We also document a decrease in the contribution to other variables such as CPI (which declines from 20% to 15%), risk-free rate (26 to 17%), spread (31 to 7%) and NEER (25 to 11%). These findings indicate that commodity plays a key role in the transmission of foreign shocks in South Africa.

Financial sector Third, we study the role of our extensions on the domestic credit sector (while again leaving the foreign economy unchanged). We remove the financial accelerator mechanism (such that the spread is always equal to zero in the domestic economy) and we assume that all households are patients (such that no households are excluded from financial markets). This experiment reduces the contribution of foreign shocks to domestic GDP from 25 to 19% (see Table 2.5). The impact of foreign shocks on other variables such as CPI (which declines from 20% to 14%), risk-free rate (26 to 16%) and NEER (25% to 21%) also decline in this case. Consistent with the fact that the financial accelerator is particularly important for investment decisions, we observe a decrease from 38 to 26% in the contribution of foreign shocks to this variable. Consumption is also affected: the variance decomposition drops from 31 to 24%. The specific structure of the financial sector has therefore amplified the effect of foreign shocks on domestic variables through the financial channel and through the inability of some households to smooth consumption when facing large foreign shocks.[38]

[37] Remember also that this baseline ALLV is a bit different from the original ALLV framework because in their analysis the dynamics of the foreign block is represented by a SVAR model

[38] Note that the effect of the financial sector could be underestimated in this model. Indeed, as reported in the appendix, the model understates the correlation between the domestic spread and activity measures such as GDP. This could indicate that the financial accelerator mechanism is underestimated. Moreover, there is no binding constraint on the amount of credit as in Iacoviello (2005) which could reinforce the importance of the financial sector for the transmission of foreign shocks. However, direct exposure to foreign financial assets was limited and

Table 2.4: Variance decomposition under different models

Foreign shocks	Baseline	No Mining	No Fin	No Inputs	ALLV
GDP	25.19	8.70	18.72	22.69	6.21
Employment	29.39	6.80	22.24	26.31	5.24
Consumption	30.87	8.09	24.29	28.07	6.45
Investment	37.63	11.14	25.81	32.61	10.67
Exports	14.18	8.76	14.42	13.08	9.00
Imports	12.62	4.20	11.68	17.25	6.40
Mining exports	21.69	0.00	19.62	14.75	0.00
CPI	20.49	15.25	13.41	17.63	7.99
MPI	27.11	21.79	25.86	20.35	11.54
Wage	27.81	10.76	17.22	21.08	10.78
Risk-free rate	26.23	17.32	15.60	23.98	11.44
Spread	31.41	6.99	0.00	30.00	0.00
NEER	24.62	11.03	21.45	16.17	8.87
SOE shocks	Baseline	No Mining	No Fin	No Inputs	ALLV
GDP	24.90	33.99	27.80	19.70	31.97
Employment	16.27	26.06	12.71	15.21	19.70
Consumption	12.23	22.56	13.00	14.67	25.97
Investment	8.70	19.55	14.43	8.43	24.14
Exports	60.88	88.68	59.45	50.28	88.06
Imports	77.48	88.55	78.23	66.91	79.88
Mining exports	4.58	0.00	4.41	3.13	0.00
CPI	26.53	38.68	26.60	35.36	37.68
MPI	66.07	73.23	68.74	71.14	81.63
Wage	14.11	27.57	13.41	19.94	24.34
Risk-free rate	20.30	39.32	22.25	25.93	35.84
Spread	4.87	7.09	0.00	2.90	0.00
NEER	68.47	83.33	72.68	77.48	84.55
Domestic shocks	Baseline	No Mining	No Fin	No Inputs	ALLV
GDP	49.41	56.77	52.88	57.13	61.14
Employment	53.89	66.58	64.44	58.02	74.30
Consumption	56.21	68.71	61.86	56.61	66.75
Investment	52.83	68.36	58.82	58.03	64.23
Exports	24.13	1.82	25.27	35.81	2.14
Imports	8.97	6.44	9.11	15.02	12.92
Mining exports	68.65	0.00	71.43	77.25	0.00
CPI	52.16	45.24	59.16	46.24	53.58
MPI	5.82	3.98	4.55	7.40	5.86
Wage	54.92	57.70	65.91	55.82	58.31
Risk-free rate	51.99	41.32	60.16	48.39	50.21
Spread	62.97	85.13	0.00	66.35	0.00
NEER	5.93	4.65	4.95	5.36	5.61

Note: This table shows the total contribution of foreign. SOE and domestic shocks on domestic variables. No Mining = No mining production in SA. No finance = closing the financial sector in SA. No Inputs = No inputs in the domestic production function. ALLV = Domestic economy modelled following ALLV.

Import structure Finally, we remove our extensions on the import structure. We now assume that there are no foreign input used in the domestic production function and also no import contents of exports is allowed. We recalibrate the shares of imports in consumption and investment to 0.19 and 0.4, respectively, in order to account for the fact that some foreign inputs would finally enter domestic consumption or investment (after being processed by domestic firms). In this case, the drop in the contribution of foreign shocks on domestic variables in modest. We, however, observe a small decrease for most domestic variables. Disaggregating the results (no reported here) shows that this small decrease comes from a lower contribution of foreign supply shocks.

2.4.6 Model validation and robustness checks

Moments of the estimated model Looking at moments observed in the data and generated using the mode of parameters (Table 2.9), we can see that our model successfully reproduces some key moments such as the correlation between: domestic and foreign GDP (data:0.40 vs DSGE:0.34); mining exports and commodity prices (0.61 vs 0.44); domestic GDP and commodity prices (0.58 vs 0.41); foreign and domestic interest rates (0.73 vs 0.32); and foreign and domestic spreads (0.45 vs 0.26).

Correlation between shocks We compute the correlations between shocks identified at the mode (see Table 2.11).[39] Although the model (as most DSGE models) still implies a number of correlated shocks, we find that domestic and foreign shocks of the same type (e.g. foreign and domestic aggregate demand shocks) tend to display a modest and positive correlation (with the exception of credit supply shocks). This indicates that the strength of transmissions channels are not over or underestimated. Moreover, there is no correlation between domestic and foreign commodity supply shocks. This finding suggests that the magnitude of the responses of domestic commodity exports to foreign commodity supply shocks is well identified. Also note that it is the study of shocks correlation that justifies our choice to introduce import content of exports, to allow for correlated import and export shocks (called trade shocks) and to introduce wedge shocks (generating a positive co-movement between consumption and investment) instead of the consumption demand shock originally present in Adolfson et al. (2007).

Calibrated parameters Here we report some evidence supporting our calibration for CES production functions. For each CES production function, we test a low (1/3) value of the elasticity of substitution between inputs against the standard value (1) implied by the Cobb-Douglas production function. We compare the log data densities (LDD) implied by each of

could justify the view that foreign credit supply shocks were transmitted through the trade channel.

[39]We assume that shocks are independent in the estimation and after the estimation we check to which extent this assumption was maintained.

these values. LDDs support a low elasticity of substitution σ_p in the commodity production function and a low elasticity of substitution σ_n between domestic and foreign inputs in the manufacturing sector, which supports our calibration presented in Section 3.3.

Table 2.5: Foreign Shocks Contribution to Domestic Variables: Sensitivity

	Baseline	One step	G7 Avg	G7 PC	Elast	W-push	1994-2010	2000-16
GDP	25.19	18.68	20.85	22.53	23.69	18.16	23.60	31.26
Employment	29.39	22.32	24.52	26.03	27.70	21.21	23.92	38.65
Consumption	30.87	23.54	22.28	23.33	25.93	21.54	25.97	39.09
Investment	37.63	29.23	24.49	23.16	28.71	37.19	33.35	39.18
Exports	14.18	8.54	11.91	8.63	14.92	12.95	12.80	16.22
Imports	12.62	8.67	11.07	9.27	12.83	11.71	10.27	11.98
Mining exp.	21.69	15.85	22.69	24.44	22.96	20.22	17.07	27.39
CPI	20.49	15.24	18.68	13.48	19.63	22.51	16.61	20.74
MPI	27.11	20.91	22.78	25.12	22.38	27.53	22.81	29.57
Wage	27.81	21.73	22.37	17.78	21.87	22.69	21.44	32.01
Risk-free rate	26.23	19.12	20.44	11.95	24.61	32.25	17.80	28.00
Spread	31.41	21.96	28.47	21.01	32.14	26.70	25.27	31.47
NEER	24.62	17.91	22.13	14.22	16.34	29.35	19.01	25.72

One-step = domestic and foreign parameters estimated jointly. G7 Avg = foreign economy proxied with average of G7 data. G7 PC = foreign economy proxied with principal component of G7 data. Elast = $\eta_c = \eta_i = \eta_f = 1.25$. W-Push = Estimation includes wage data and a wage-push shock. 1994-2010 = estimation on a sub-sample stopping in 2010Q1 and 2000-16 = estimation on a sub-sample starting in 2000Q1.

Sub-period analysis We also experiment with different sample data periods. For instance, we tried starting the estimation period in 2000Q1 (to exclude the pre- formal inflation targeting monetary regime in South Africa) as well as ending the sample period in 2010Q1 (to avoid the ZLB and QE periods in the US). Our results remain qualitatively unchanged although the role of foreign has been a bit amplified when the sample period of 2000-2016 is used (see Table 2.5).

Identification of global shocks We check the robustness of results to different datasets and strategies used in order to estimate foreign parameters and global shocks. Remember that our baseline analysis use US data and estimate foreign parameters separately (without domestic data) for the 1994Q1-2016Q1 period. We now experiment with different strategies using G7 data (computed with a simple mean or a principal component) and estimating domestic and foreign parameters jointly (see Table 2.5). The contribution of foreign shocks to South African GDP remains important although it has decreased a bit in comparison with the baseline analysis. This small decrease is due to the fact that aggregating over G7 countries reduces the variance of foreign variables (and therefore lead to smaller shocks) and to the fact that some foreign parameters are affected by domestic data when the estimation is performed in a single step (e.g. the elasticity of substitution of commodities). Finally, we replace the fed fund rate by the shadow rate (proposed by Wu and Xia (2016)) and our main result remain qualitatively unchanged.

Identification of wage push shocks Considering the particular nature of the South African labour market, characterised by powerful unions and very large unemployment rates, we estimated our model excluding wage push shocks in the baseline estimation. We perform a robustness exercise introducing wage push shocks together with wage data. In this case, the model identifies large wage push shocks accounting for about 7% and 11% of the fluctuations in GDP and consumption, respectively. This results in a lower contribution of foreign shocks for those specific variables.

Elasticity of substitution between domestic and foreign goods We finally investigate the role of the elasticity of substitution between domestic and foreign consumption and investment goods in the domestic and foreign economies. Our estimates indicate lower values than what is usually described in the literature. We therefore re-estimated the model calibrating those parameters to 1.25. We find that this experiment slightly reduces the share of foreign shocks and our main results remain qualitatively unchanged (see Table 2.5).

2.5 Conclusion

We extend a standard SOE-DSGE model to account for various specificities of advanced and emerging economies allowing to better capture the transmission of foreign shocks in a small open economy. The most important extensions are the introduction of mining and financial sectors in both economies. We estimate the model with Bayesian methods using data from South African and G7 countries. We identify a wide range of foreign and domestic (aggregate demand, aggregate supply, monetary policy, credit and commodity supply) shocks and study their relative importance in macroeconomic fluctuations in South Africa. Besides, we include SOE (trade and risk premium) shocks.

We find that, in contrast to standard SOE-DSGE models, foreign shocks explain about 30% of macroeconomic fluctuations in South Africa. In particular, they account for about 25% of the variability in real activity in South Africa. These findings are in line with the predictions of SVAR model (e.g. Houssa et al. (2015)). The model is also able to replicate the observed positive co-movement between real activities in advanced countries and South Africa. Typical foreign (aggregate demand, supply, credit and monetary policy) shocks reproduce this positive correlation and endogenous commodity price is key in explaining this result. Exogenous foreign commodity supply shocks are also very important drivers of economic fluctuations in

South Africa. They are also good candidates to explain the observed excess volatility in consumption and the large fluctuations in investment of South Africa. They generate, however, a negative co-movement between foreign and domestic business cycles. Domestic and SOE shocks also matter for macroeconomic fluctuation in South Africa. For instance, they explain about 50 and 25% of fluctuation in the South African GDP, respectively. As such, any appropriate stabilization policies should take into account both these domestic and external (foreign and SOE) shocks.

Historical decomposition shows that the recent global financial crisis was mainly transmitted to South Africa via adverse foreign aggregate demand, credit supply and SOE shocks. Positive commodity supply shocks contributed to the 2011 recovery before the current commodity price reversal. Going further back in time, we see that commodity prices played a major role in the 1998 rand crisis.

Our framework also allows us to explore more precisely the transmission channels of foreign shocks. By shutting down some our extended channels one at a time, we find that the large share of commodities in South African exports plays an important role in the transmission of foreign shocks and that the financial channel has contributed to amplifying the fluctuations caused by those shocks.

A number of interesting research questions emerge from the framework presented in this paper. For instance, the fact that SOE also play a significant role in macroeconomic fluctuation in South Africa motivate the need to appropriately study their origins. One possibility would be to extend the model to include a block of other emerging markets economies with which South African's linkages have been intensified in recent years. In any case our framework already provides a good basis for the design of monetary and fiscal policies that could stabilize the domestic economy in the face of the various shocks identified in the paper. It would be also interesting to apply this model to other emerging economies or Sub-Saharan African countries where data availability is an issue by (using South-Africa as a prior and/or using a panel data approach). All these interesting issues are on our research agenda.

Table 2.6: Calibrated Parameters

Parameter	Domestic Parameters	Baseline Value
h	Hours devoted to work	0.3000
μ_z	Mean GDP growth rate	1.0063
$\bar{\pi}$	Mean inflation rate - Inflation target	1.0113
R	Mean risk-free rate	1.0300
R^L	Mean Lending rate	1.0400
ν	Share of working capital paid in advance	1.0000
ν_n	Share of inputs paid in advance	1.0000
ω_b	Share of foreign banks in domestic credit	0.2200
ω_k	Share of foreign assets in domestic bank	0.0600
δ_e	Entrepreneurs "death" rate	0.0100
$\frac{b_e}{y}$	Entrepreneurs loan to GDP ratio	1.0000
τ_k	Capital gain taxes	0.2000
τ_w	Pay-roll tax	0.0500
τ_y	Labour income taxes	0.0300
τ_c	Value added tax	0.1400
δ	Capital depreciation rate	0.0200
α_d	Capital income share in final good sector	0.3000
α_p	Capital income share in primary sector	0.1800
λ_d	Mark-up final good	1.2500
λ_w	Mark-up labour market	1.2500
$\frac{y^p}{y}$	Share of mining sector in GDP	0.1000
ω_h	Share of mining sector in employment	0.0670
ω_c	share of imports in consumption	0.1000
ω_i	share of imports in investment	0.3300
ω_n	share of foreign inputs in final good	0.1000
ω_x	Import content of exports	0.2000
$\frac{a}{y}$	Foreign Debt to quarterly GDP ratio	-0.800
$\frac{g}{y}$	Government consumption to GDP ratio	0.1950
σ_c	Consumption substitution elasticity	1.0000
σ_l	Labour suply elasticity	2.0000
ϕ_a	Debt-elastic foreign interest rate	0.0001
ξ_w	Calvo wages	0.700
κ_d	Indexation final good	0.100
κ_m	Indexation imports	0.100
κ_x	Indexation exports	0.100
κ_w	Indexation wages	0.650
σ_a	Capital variable utilisation (final)	10.000
σ_{ap}	Capital variable utilisation (mining)	10.000
η_h	Labour mobility	1.000
σ_d	Labour-Capital substitutability (final good)	1.000
σ_n	Domestic-Foreign input substitutability	0.330
σ_p	Labour-Capital substitutability (mining)	0.330
	Foreign Parameters	
α^*	Capital income share	0.250
β^*	Commodities income share	0.050
$\frac{f^{e*}}{y^*}$	Entrepreneurs loans to GDP ratio	2.000
κ^*	Indexation final good	0.200

Table 2.7: Estimated Parameters in the joint estimation

	Domestic Parameters	Mode	Post Std	Post 5%	Post 95%	Pr Mean	Pr Std	Pr shape
ξ_d	Calvo final good	0.719	0.028	0.674	0.760	0.650	0.050	BETA
ξ_m	Calvo impots	0.639	0.041	0.577	0.704	0.650	0.050	BETA
ξ_x	Calvo exports	0.735	0.036	0.676	0.794	0.650	0.050	BETA
ξ_e	Labour hoarding	0.482	0.034	0.423	0.534	0.500	0.250	BETA
$\tilde{S}''$	Investment adjustment cost	7.149	0.637	6.100	8.084	3.500	1.000	NORMAL
b	External habbits	0.784	0.026	0.734	0.820	0.700	0.050	BETA
η_f	Exports price elasticity	0.809	0.150	0.583	1.067	1.500	1.000	INV GAMMA
η_c	Domestic-Foreign cons. elast. subst.	0.481	0.060	0.389	0.581	1.500	1.000	INV GAMMA
ρ_r	CB interest rate smoothing	0.877	0.011	0.855	0.889	0.800	0.050	BETA
τ_π	CB inflation response	1.711	0.075	1.588	1.829	1.500	0.100	NORMAL
τ_x	CB depreciation reponse	0.106	0.021	0.073	0.139	0.125	0.025	NORMAL
$\tau_{\delta y}$	CB GDP growth response	0.482	0.091	0.343	0.640	0.250	0.100	NORMAL
ϕ_{nw}	Wholesale rate response to net worth	0.016	0.003	0.012	0.021	0.050	0.050	INV GAMMA
δ_l	Land depreciation	0.325	0.068	0.221	0.434	0.330	0.100	BETA
	Foreign Parameters	**Mode**	**Post Std**	**Post 5%**	**Post 95%**	**Pr Mean**	**Pr Std**	**Pr shape**
σ_d^*	Commodity subst.	0.258	0.036	0.214	0.331	0.250	0.100	BETA
ξ^*	Calvo final good	0.766	0.024	0.730	0.805	0.650	0.050	BETA
κ_w^*	Indexation labour market	0.344	0.037	0.283	0.404	0.500	0.050	BETA
ξ_w^*	Calvo labour market	0.835	0.022	0.797	0.867	0.700	0.050	BETA
b^*	External habbits	0.769	0.029	0.725	0.814	0.700	0.050	BETA
ρ_{r*}	Foreign Monetary Policy	0.907	0.008	0.892	0.920	0.850	0.050	BETA
τ_π^*	CB inflation response	1.903	0.090	1.771	2.064	1.750	0.100	GAMMA
$\tau_{\Delta y}^*$	CB GDP growth response	0.282	0.109	0.151	0.550	0.250	0.100	GAMMA
τ_y^*	CB GDP gap response	0.016	0.008	0.005	0.033	0.050	0.025	GAMMA
ϕ_{nw*}	Lending rate response to net worth	0.032	0.008	0.022	0.049	0.050	0.025	INV GAMMA
δ_l^*	Land depreciation	0.051	0.007	0.041	0.065	0.050	0.010	BETA
$\tilde{S}_*''$	Investment adj costs	2.239	0.407	1.667	2.954	3.500	1.500	GAMMA
ω_s^*	spread elasticity to risk premium	0.857	0.086	0.687	0.955	0.800	0.100	BETA

Table 2.8: Estimated Shocks in the joint estimation

	Shock coef	Save Mode	Post Std	Post 5%	Post 95%	Pr Mean	Pr Std	Pr shape
ε_b^*	AR(1)	0.88	0.02	0.85	0.91	0.80	0.10	BETA
ε_k^*	AR(1)	0.98	0.01	0.96	1.00	0.90	0.10	BETA
λ_w^*	AR(1)	0.11	0.03	0.07	0.16	0.50	0.10	BETA
ε_R^*	AR(1)	0.21	0.07	0.11	0.31	0.25	0.10	BETA
ε_{RL}^*	AR(1)	0.83	0.04	0.74	0.88	0.90	0.10	BETA
λ_d^*	AR(1)	0.26	0.06	0.18	0.35	0.50	0.10	BETA
Υ^*	AR(1)	0.84	0.05	0.70	0.88	0.80	0.10	BETA
ε_g^*	AR(1)	0.70	0.06	0.59	0.80	0.80	0.10	BETA
$\tilde{\phi}$	AR(1)	0.82	0.05	0.74	0.88	0.80	0.10	BETA
ε_x	AR(1)	0.80	0.07	0.67	0.91	0.60	0.10	BETA
ε_x	MA(1)	0.41	0.09	0.27	0.57	0.60	0.10	BETA
ε_m	AR(1)	0.69	0.07	0.57	0.80	0.60	0.10	BETA
ε_m	MA(1)	0.46	0.08	0.32	0.59	0.60	0.10	BETA
ε_k	AR(1)	0.85	0.04	0.78	0.91	0.80	0.10	BETA
ε_{RL}	AR(1)	0.85	0.03	0.80	0.89	0.80	0.05	BETA
λ_d	AR(1)	0.45	0.07	0.32	0.54	0.50	0.10	BETA
λ_m	AR(1)	0.44	0.07	0.31	0.54	0.50	0.10	BETA
ε_b	AR(1)	0.95	0.03	0.90	0.98	0.80	0.10	BETA
Υ	AR(1)	0.50	0.07	0.36	0.59	0.80	0.10	BETA
	Shock Std	Save Mode	Post Std	Post 5%	Post 95%	Pr Mean	Pr Std	Pr shape
ε_b^*	Std	0.21	0.04	0.15	0.29	0.50	0.50	INV GAM
ε_k^*	Std	1.27	0.11	1.11	1.48	0.50	0.50	INV GAM
λ_w^*	Std	1.89	0.26	1.48	2.28	0.50	0.50	INV GAM
ε_R^*	Std	0.14	0.02	0.12	0.16	0.20	0.20	INV GAM
ε_{RL}^*	Std	0.13	0.02	0.11	0.17	0.20	0.20	INV GAM
ε_L^*	Std	2.63	0.45	2.03	3.51	0.50	0.50	INV GAM
λ_d^*	Std	3.59	0.42	2.96	4.29	0.50	0.50	INV GAM
Υ^*	Std	0.28	0.09	0.18	0.69	0.50	0.50	INV GAM
ε_g^*	Std	0.89	0.15	0.69	1.15	0.50	0.50	INV GAM
$\tilde{\phi}$	Std	0.97	0.22	0.67	1.34	0.05	0.05	INV GAM
ε_x	Std	3.11	0.24	2.75	3.53	0.50	0.50	INV GAM
ε_m	Std	3.30	0.21	2.95	3.66	0.50	0.50	INV GAM
ε_k	Std	3.10	0.37	2.57	3.83	0.50	0.50	INV GAM
ε_R	Std	0.17	0.02	0.15	0.21	0.20	0.20	INV GAM
ε_{RL}	Std	0.24	0.02	0.21	0.27	0.20	0.20	INV GAM
ε_L	Std	7.29	0.49	6.57	8.17	0.50	0.50	INV GAM
λ_d	Std	2.04	0.29	1.59	2.48	0.30	2.00	INV GAM
λ_m	Std	8.73	1.40	6.68	11.16	0.30	2.00	INV GAM
ε_b	Std	0.19	0.07	0.13	0.34	0.10	0.10	INV GAM
Υ	Std	13.81	2.41	10.49	18.59	0.20	0.50	INV GAM
$\varepsilon_x, \varepsilon_m$	$corr(\varepsilon_x, \varepsilon_m)$	0.84	0.07	0.72	0.96	0.50	0.50	INV GAM

Table 2.9: Moments: Data vs DSGE at its mode: selected domestic variables

	Std(z)		Corr(z,GDP)		Corr(z,CPI)		Corr(z,R)		Corr(z,Spr)		Corr(z,Com)		Corr(z,NEER)	
	Data	DSGE	Data	DSGE	Data	DSGE	Data	DSGE	Data	DSGE	Data	DSGE	Data	DSGE
GDP	1.75	2.51	1.00	1.00	-0.11	-0.15	-0.02	-0.13	-0.58	-0.12	0.61	0.30	-0.01	-0.02
Employment	2.13	3.05	0.74	0.75	-0.05	-0.10	-0.13	-0.21	-0.61	-0.08	0.42	0.07	0.11	-0.06
Consumption	2.47	2.93	0.83	0.78	-0.31	-0.32	-0.06	-0.31	-0.61	-0.14	0.59	0.00	0.05	-0.08
Investment	6.26	6.45	0.60	0.50	0.17	-0.01	0.10	-0.09	-0.66	-0.18	0.23	-0.05	0.10	-0.04
Exports	6.24	6.80	0.59	0.39	-0.12	-0.07	-0.09	0.00	-0.37	0.03	0.74	0.29	0.09	0.03
Imports	7.12	7.13	0.60	0.16	-0.14	-0.16	-0.09	-0.15	-0.52	-0.05	0.61	0.57	0.16	-0.04
Mining exports	9.49	8.24	0.61	0.57	-0.22	-0.11	-0.13	-0.04	-0.20	0.01	0.42	0.29	0.13	0.03
CPI	2.62	2.73	-0.11	-0.15	1.00	1.00	0.51	0.74	0.17	-0.15	0.59	0.32	0.01	0.06
MPI	8.82	8.82	0.28	-0.10	0.45	0.51	0.28	0.38	0.07	-0.02	0.23	0.14	0.45	0.12
Wage	2.98	3.19	-0.16	-0.08	0.35	0.68	0.35	0.61	0.21	-0.18	0.74	0.59	0.16	0.02
Risk-free rate	4.14	3.05	-0.02	-0.13	0.51	0.74	1.00	1.00	0.16	-0.18	0.62	0.21	0.04	0.11
Spread	1.58	1.46	-0.58	-0.12	0.17	-0.15	0.16	-0.18	1.00	1.00	1.00	1.00	-0.08	-0.01
NEER	5.69	5.85	-0.01	-0.02	0.01	0.06	0.04	0.11	-0.08	-0.01	-0.22	-0.11	1.00	1.00
US GDP	1.80	2.13	0.40	0.34	-0.25	-0.08	0.35	-0.07	-0.26	-0.04	0.26	-0.06	0.00	-0.03
US Consumption	1.65	1.97	0.32	0.35	-0.30	-0.11	0.41	-0.08	-0.20	-0.04	0.07	0.02	0.07	-0.04
US Investment	5.29	6.34	0.32	0.30	-0.24	-0.03	0.26	-0.04	-0.25	-0.04	-0.13	-0.04	0.09	-0.03
US Hours	2.57	3.28	0.45	0.34	-0.19	-0.08	0.05	-0.08	-0.39	-0.02	-0.20	0.01	0.16	-0.01
US CPI	1.73	2.13	0.64	0.07	0.03	0.29	0.07	0.22	-0.17	-0.08	0.13	0.03	-0.07	0.01
US Wage	1.63	1.85	0.23	0.05	-0.27	0.26	0.34	0.22	-0.05	-0.10	0.34	0.33	0.12	0.05
US Risk-free rate	2.34	1.79	0.38	-0.09	0.21	0.29	0.73	0.32	-0.09	-0.11	0.29	0.30	0.11	0.04
US Spread	0.95	1.10	-0.35	-0.15	0.39	-0.12	-0.10	-0.16	0.45	0.26	0.29	0.28	0.15	0.02
Commodity Price	17.93	19.92	0.58	0.41	-0.15	-0.15	-0.08	-0.16	-0.23	0.02	0.42	0.35	-0.09	-0.15

Note: Risk-free rate and spread in levels; NEER in Q/Q growth rate; all other variables in Y/Y growth rates.

Table 2.10: Moments: Data vs DSGE at its mode: selected foreign variables

	Corr(z,GDP*)		Corr(z,CPI*)		Corr(z,R*)		Corr(z,Spr*)		Corr(z,CP*)	
	Data	DSGE	Data	DSGE	Data	DSGE	Data	DSGE	Data	DSGE
GDP	0.40	0.34	0.64	0.07	0.38	-0.09	-0.35	-0.15	0.61	0.44
Employment	0.23	0.36	0.42	0.09	0.23	-0.09	-0.21	-0.12	0.33	0.42
Consumption	0.42	0.27	0.47	-0.02	0.41	-0.13	-0.49	-0.13	0.55	0.40
Investment	0.14	0.17	0.32	0.05	0.26	-0.02	-0.12	-0.13	0.27	0.25
Exports	0.38	0.26	0.41	0.04	0.21	-0.06	-0.27	-0.03	0.37	0.21
Imports	0.46	0.15	0.38	-0.06	0.18	-0.07	-0.36	-0.04	0.52	0.18
Mining exports	0.34	0.33	0.54	0.00	0.20	-0.10	-0.22	-0.10	0.61	0.44
CPI	-0.25	-0.08	0.03	0.29	0.21	0.29	0.39	-0.12	-0.15	-0.15
MPI	0.00	-0.14	0.23	0.27	0.36	0.19	0.28	0.01	-0.02	-0.24
Wage	-0.01	-0.04	0.01	0.18	0.24	0.21	0.08	-0.14	0.15	-0.07
Risk-free rate	0.35	-0.07	0.07	0.22	0.73	0.32	-0.10	-0.16	-0.08	-0.16
Spread	-0.26	-0.04	-0.17	-0.08	-0.09	-0.11	0.45	0.26	-0.23	0.02
NEER	0.00	-0.03	-0.07	0.01	0.11	0.04	0.15	0.02	-0.09	-0.15
US GDP	1.00	1.00	0.30	-0.01	0.49	-0.26	-0.74	-0.28	0.26	0.65
US Consumption	0.90	0.92	0.17	-0.08	0.56	-0.31	-0.68	-0.23	0.17	0.61
US Investment	0.92	0.88	0.28	0.06	0.37	-0.18	-0.68	-0.33	0.14	0.55
US Hours	0.79	0.93	0.33	0.02	0.35	-0.26	-0.66	-0.25	0.23	0.67
US CPI	0.30	-0.01	1.00	1.00	0.32	0.52	-0.22	-0.10	0.73	-0.02
US Wage	0.41	0.04	0.18	0.61	0.51	0.33	-0.27	-0.13	0.14	-0.02
US Risk-free rate	0.49	-0.26	0.32	0.52	1.00	1.00	-0.36	-0.06	0.14	-0.23
US Spread	-0.74	-0.28	-0.22	-0.10	-0.36	-0.06	1.00	1.00	-0.27	-0.17
Commodity Price	0.26	0.65	0.73	-0.02	0.14	-0.23	-0.27	-0.17	1.00	1.00

Note: Risk-free rate and spread in levels; NEER in Q/Q growth rate; all other variables in Y/Y growth rates.

Table 2.11: Shocks Correlation

	$\varepsilon^*_{k.t}$	$\varepsilon^*_{R.t}$	$\varepsilon^*_{R_L.t}$	$\varepsilon^*_{L.t}$	$\lambda^*_{d.t}$	$\lambda^*_{w.t}$	$\varepsilon^*_{b.t}$	Υ^*_t	$\varepsilon^*_{g.t}$	$\varepsilon_{x.t}$	$\varepsilon_{m.t}$	$\tilde{\phi}_t$	$\varepsilon_{k.t}$	$\varepsilon_{R.t}$	$\varepsilon_{R_L.t}$	$\varepsilon_{L.t}$	$\lambda_{d.t}$	$\lambda_{m.t}$	$\varepsilon_{b.t}$	Υ_t
$\varepsilon^*_{k.t}$	-																			
$\varepsilon^*_{R.t}$	0.16	-																		
$\varepsilon^*_{R_L.t}$	0.29	0.29	-																	
$\varepsilon^*_{L.t}$	-0.02	-0.59	-0.35	-																
$\lambda^*_{d.t}$	-0.14	-0.69	-0.52	0.61	-															
$\lambda^*_{w.t}$	-0.01	-0.03	-0.05	-0.08	-0.12	-														
$\varepsilon^*_{b.t}$	0.17	-0.17	0.14	0.20	0.00	-0.11	-													
Υ^*_t	0.14	0.35	0.06	-0.31	-0.34	-0.04	-0.03	-												
$\varepsilon^*_{g.t}$	0.34	0.09	0.25	-0.09	-0.26	0.25	-0.05	0.32	-											
$\varepsilon_{x.t}$	-0.06	-0.18	0.00	0.14	0.07	-0.21	-0.12	0.04	0.02	-										
$\varepsilon_{m.t}$	-0.14	0.06	-0.13	0.06	0.03	-0.11	0.26	0.17	-0.05	-0.19	-									
$\tilde{\phi}_t$	-0.07	0.18	-0.28	0.01	0.07	0.26	-0.22	-0.05	0.01	-0.41	0.29	-								
$\varepsilon_{k.t}$	0.18	0.19	0.22	-0.18	-0.19	-0.16	0.17	0.16	0.06	-0.06	0.27	-0.04	-							
$\varepsilon_{R.t}$	-0.27	0.22	-0.04	-0.33	-0.17	0.16	-0.41	0.09	0.08	-0.19	-0.03	0.33	0.04	-						
$\varepsilon_{R_L.t}$	-0.12	-0.19	-0.19	0.03	0.07	0.13	0.02	-0.08	-0.12	-0.07	0.07	0.11	0.17	-0.01	-					
$\varepsilon_{L.t}$	-0.10	0.06	-0.02	0.00	-0.02	-0.01	0.06	0.08	-0.10	0.08	0.33	-0.15	-0.02	0.03	-0.13	-				
$\lambda_{d.t}$	-0.16	-0.17	-0.20	0.30	0.29	-0.01	0.08	-0.31	-0.06	-0.07	0.03	0.02	0.05	0.01	0.02	-0.07	-			
$\lambda_{m.t}$	0.27	0.03	0.22	0.17	-0.09	-0.11	0.28	-0.13	-0.02	0.20	-0.22	-0.45	-0.16	-0.47	-0.19	-0.12	-0.18	-		
$\varepsilon_{b.t}$	-0.24	-0.36	-0.19	0.29	0.24	-0.03	0.32	-0.16	-0.16	-0.38	0.28	0.10	0.09	-0.26	0.17	-0.23	0.11	-0.05	-	
Υ_t	-0.13	-0.03	-0.42	0.03	0.25	-0.05	-0.09	0.16	-0.02	-0.19	0.28	0.26	0.09	0.09	0.04	-0.05	-0.08	-0.28	0.20	-
$\varepsilon_{g.t}$	0.22	0.18	0.15	-0.03	-0.08	0.00	-0.12	-0.01	0.26	-0.37	-0.16	0.15	0.12	0.17	-0.06	-0.46	0.09	0.05	0.13	-0.08

Chapter 3

Welfare costs of business cycles and monetary policies

3.1 Introduction

Emerging countries face large business cycle shocks - such as commodity term of trade shocks - exacerbated by incomplete financial markets. These specificities generate strong GDP and price fluctuations and consumption tends to be more volatile than output. Moreover, aggregate volatility could hide much larger consumption fluctuations at the household's level and could even cause large income dispersion, especially in a context of low financial inclusion.[1] In a typical New-Keynesian DSGE model, business cycle shocks combine to idiosyncratic risks - such as Calvo price and wage rigidities or unemployment risks - to breed potentially large income dispersion. It is generally assumed that households trade in state-contingent asset markets to edge against those idiosyncratic risks. Households therefore remain homogeneous: they all have access to the same consumption basket. In this context, fluctuations in aggregate income - not individual income - matter for welfare. While this assumption preserves the representative agent frameworks, its empirical validity is questionable. In fact, an extensive body of research applied to the US challenges the perfect financial markets hypothesis and shows that it has an impact on welfare cost estimates.[2] When agents face idiosyncratic risks in the labour market, the welfare costs of business cycles are much larger for those excluded from the credit markets and for those with little wealth. Moreover, this assumption is at odd with the fact that a significant share of households are excluded from financial markets in emerging countries. However,

[1]Breen and García-Peñalosa (2005) show that business cycle volatility (measured as the standard deviation of GDP growth) causes larger income dispersion (measured as Gini coefficients) on a large set of developed and developing countries. Park and Mercado (2015), Naceur and Zhang (2016) and Turégano and Herrero (2018) find a negative link between financial access and income inequality.

[2]Imrohoruglu (1989) introduced imperfect financial markets and unemployment risks to study the welfare costs of business cycles. Many papers followed her lead including Atkeson and Phelan (1994), Krusell and Smith (1999), Beaudry and Pages (2001), Gomes et al. (2001), Krebs (2007) and many others.

this issue has been ignored and the typical NK-DSGE model with perfect insurance markets has been used to measure welfare and perform monetary policy analyses.

This paper evaluates the welfare cost of business cycles and the effects of stabilisation policies in an estimated New-Keynesian DSGE model with labour market idiosyncratic risks and imperfect financial markets inclusion. The model is taillored to an emerging economy (South Africa) and inspired from the second chapter of this dissertation (Houssa et al. (2018)). It consists of two blocks: a domestic small open emerging economy and a foreign economy which captures the exposure of the domestic economy to development in the rest of the world. Two alternative versions of the model are considered to capture idiosyncratic risks in the labour market. The first version introduces monopolistic competition with Calvo wage rigidities (henceforth EHL) developed in Erceg et al. (2000). This feature has been widely applied in the DSGE literature and used in the second chapter. Moreover, it offers a natural benchmark to test the influence of idiosyncratic risks. The second version develops search and matching frictions with staggered wage bargaining (hereafter GTT) following Gertler and Trigari (2009) and Thomas (2008). These ingredients fit the institutional framework in South Africa. The model also incorporates two dimensions that are particularly relevant to characterise the business cycle in a small open emerging economy. First, it includes two categories of households that differ with respect to access to capital and financial markets. Households excluded from these markets own no physical capital or bonds and simply consume their entire labour income in every period as in Mankiw (2000). In addition, they do not trade in state-contingent asset markets and do not insure against idiosyncratic risks.[3] Second, there are two different types of goods in the domestic and foreign economies: primary and secondary products. The emerging economy exports commodities whose prices are endogenously determined in the foreign block.[4] Within this framework, monetary policy is modelled as Taylor rule with interest rate smoothing and responds to CPI-inflation deviation from target, to the GDP growth rate and to changes in the nominal exchange rate. This rule reflects the gradual move among emerging economies from exchange rate management to inflation targeting that followed the currency crisis in the 1990s and accomodates output stabilisation motives.[5] The model is estimated with Bayesian methods on South African and US data. The welfare costs of business cycles are expressed as a fraction of consumption following Lucas (1987) and measured using a second order approximation to

[3]This feature captures the unequal access to capital and financial markets. In middle income countries, only 55% of the population over 15 years has an account at a financial institution (compared to 63% in SA and 92% in the US) and only 21% has some form of formal savings (26% in SA 56% in the US). World Bank, Financial Inclusion Database, 2011-2017 average.

[4]Many developing and emerging countries are dependant on commodities. UNCTAD (2016) considers 91 developing countries as "commodity dependant". They include all countries with a commodity exports to total merchandises exports ration above 60% for the 2014-2015 period. South Africa is just bellow this threshold with 55% in that period.

[5]Since February 2000, the South African Reserve Bank (SARB) operates in a formal inflation targeting framework with a dual objective of consumer price and output stabilisation. Similar Taylor rules have been widely used to describe monetary policy in South Africa (e.g. Ortiz and Sturzenegger (2007)).

the model.

The results show that the welfare costs of business cycles are relatively large for each category of households in the emerging economy confirming a previous strand of empirical research (see Pallage and Robe (2003) and Houssa (2013)). This measure differs in the sense that it relies on a structural model whose parameters are estimated on a large set of observed variables. As argued by Otrok (2001), estimated models bring discipline to the choice of parameters and capture agents endogenous responses to shocks. Moreover, this paper shows that the welfare costs are much larger for households excluded from asset markets especially because of their inability to insure against labour market idiosyncratic risks. Indeed, while their costs represent 1.5 to 8 times those endured by included households, they would approximately be equal if they could mute the idiosyncratic risk. Business cycle swings illustrate the idiosyncratic risk mechanism. In the EHL framework, a typical economic downturn encourages households to reduce their wage. But wages rigidities entail wage dispersion: only a faction of agents adjust while others simply index their wages. Monopolistic competition then implies that households stuck with relatively high hourly wages suffer a drastic drop in hours worked and labour income. In the GTT framework, the same downturn leads to a drop in wages for the fraction of households facing wage renegotiations as well as to a rise in unemployment. In both versions of the model, financially included households trade in state-contingent securities to mute these risks while luckless excluded households have to cut on consumption expenditures. Since households are risk averse, this consumption dispersion has a detrimental aggregate welfare effect.

This paper subsequently decomposes the welfare effects of different types of shocks. It finds that both domestic demand and supply shocks have large welfare effects hinting that there is both scope and limitation for demand management policies. Foreign shocks also have important welfare repercussions in the emerging economy. Surprisingly, some business cycles shocks - such as foreign commodity supply shocks - could be welfare increasing for financially included households while this is not as likely for the other category. Commodity price fluctuations offer option effects: firms have the opportunity to transfer production from low commodity price periods to high commodity price periods in order to increase their average income per unit. These gains dominate the adverse welfare effects of aggregate fluctuations when the elasticity of factor supply is sufficiently large and when agents have an effective mean to store wealth in capital or foreign bonds.[6]

The estimated Taylor Rule captures the behaviour of the South African Reserve Bank, which consistently responded to inflation fluctuations. Moreover, it placed an average weight on GDP growth and a smaller weight on the change in the nominal exchange rate. This paper finds that a more aggressive anti-inflation stance would bring sizeable and robust welfare gains for each category of households. The optimal simple rule (computed at the mode of estimated

[6]Lester et al. (2014) and Cho et al. (2015) show that TFP shocks could be welfare enhancing in a RBC model and describe similar option effects.

parameters) depends on the assumptions made in the labour market.[7] In the EHL framework, a strong and immediate response to inflation deviation from target maximises welfare for each type of agents. In the GTT version, excluded households benefit from an immediate and strong response to inflation and output, while included households desire to place a moderate weight on output. From an utilitarian perspective, the optimal rule is a compromise. The welfare gains associated to these optimal simple rules compared to the benchmark are relatively large. Included households would be ready to give-up 0.13% and 0.25% of consumption to implement the optimal simple rule in the EHL and GTT frameworks; respectively. Excluded households gain even more: they would renounce to 0.62% and 0.39% of consumption in the EHL and GTT environments. Most of these gains come from mitigating the effects of domestic demand shocks. However, the welfare cost of business cycles remains substantial. Included households would abandon 0.38% of consumption to insulate the economy from aggregate fluctuations in the EHL framework and 0.45% in the GTT variant. Excluded households still endure larger costs equivalent to 1.72% and 0.84% of consumption in these two different versions.

The remainder of this chapter is organised as follows. Section two reviews the relevant literature. Section three describes the labour market institutions in South Africa. Section four presents the model and section five the empirical strategy. Section six shows the results. Finally, section seven concludes.

3.2 State of the art

3.2.1 The welfare cost of business cycles

In a seminal work, Lucas (1987) measured the welfare cost of aggregate fluctuations based on a specification of preferences and a time series representation of the aggregate consumption process. He considered a standard CRRA utility function and a trend-stationary IID consumption process matching the mean and variance of US data. Moreover, he assumed the existence of market where individuals can insure against idiosyncratic risks. He expressed a welfare loss as a fraction of consumption that agents would be willing to pay in order to avoid aggregate consumption fluctuations. Using US data over the 1947-2001 period, Lucas (2003) calculates that the welfare costs of business cycles would be as lower than one-tenth of a percent of permanent consumption. The literature then produced different competing models whose welfare costs estimates range from minor to substantial in advanced countries.

[7] Simple rules determine the response of policy variables as a function of a small number of easily observable macroeconomic indicators (such as inflation, output and exchange rate measures). Their simplicity and efficiency make them particularly attractive as stabilisation tools. Optimal simple monetary policy rules often deliver a virtually identical level of welfare compared to the optimal Ramsey policy. See for e.g. Schmitt-Grohe and Uribe (2007) and Gali and Monacelli (2005). These rules were also used in NK-DSGE model adapted to fit small open emerging countries specificities by Hove et al. (2015), Iyer (2016) and Prasad and Zhang (2015).

Departures from Lucas assumptions include a variety of utility functions and different processes governing consumption flows. Obstfeld (1994) and Dolmas (1998) experiment with different consumption processes - including persistent and permanent disturbances - and with utility functions distinguishing between risk aversion and intertemporal elasticity of substitution - such as Epstein and Zin (1989) preferences (EZ) - leading to potentially larger welfare costs estimates. Storesletten et al. (2001) show that households consumption is persistent in US data, and that their variance is larger during aggregate downturns. They model aggregate TFP shocks that interact with heteroskedastic and persistent shocks to individual labour market productivity. They find that the costs associated to business cycle fluctuations are relatively large, even for moderate levels of risk aversion. Tallarini (2000) uses EZ preferences in order to increase the risk aversion coefficient while holding the intertemporal elasticity of substitution constant. This strategy improves the predictions of a stochastic growth model and also results in large welfare costs.

Discrepancies in welfare cost estimates and their dependence on the utility function call for a consistent treatment of its parameters. Otrok (2001) argues that an estimated business cycle model would bring discipline to the choice of preferences and consumption process. He evaluates welfare costs in a RBC model with parameters estimated on US consumption and investment data and finds that welfare costs are close to Lucas (1987) estimates. Lester et al. (2014) and Cho et al. (2015) extend the debate by arguing that macroeconomic volatility might have a positive effect on welfare. Although households prefer smooth consumption plans, firms might benefit from mean-preserving productivity fluctuations. Indeed, they have the opportunity to use more inputs when their marginal productivity is high. This strategy raises their average productivity levels. Volatility can be welfare increasing when these options effects dominate the costs of consumption fluctuations. This is more likely when the elasticity of factor supply is large and when households have a mean (such as capital) to transfer wealth across periods. This result illustrates the importance of using a model that capture agents reactions to shocks when measuring the welfare costs of business cycles. Moreover, it means that the welfare costs of business cycles are unlikely to be large in RBC models with perfect asset markets. However, New Keynesian models usually attribute larger welfare costs to business cycle fluctuations even when using this assumption. From the New-Keynesian perspective, recessions feature inefficient drops in output, below its natural level. In addition to aggregate consumption and hours fluctuations, those models generates additional welfare costs arising from prices and wages rigidities.

Other studies challenge agents homogeneity and the perfect market hypothesis allowing each individual households to insure against idiosyncratic risks. Imrohoruglu (1989) considers employment idiosyncratic risks together with imperfect credit markets in the form of liquidity constraints. Business cycles are characterised by good times (high employment probability) and bad times (low employment probability). When agents only have access to a simple storage technology (with no borrowing opportunities), business cycles generate costs that are four to five times larger compared to the perfect insurance market environment. However, when agents are allowed to borrow (at an exogenous rate set to 8%), the costs are substantially reduced and closer to Lucas experiment. Building on this study, Krusell and Smith (1999) and Krusell et al. (2009) additionally consider the fact that wealth is heavily concentrated in the US. In the presence of borrowing constraints, the welfare costs of business cycles are much larger for households with little wealth. Indeed, prolonged periods of unemployment quickly exhaust poor households wealth with large welfare effects.

The literature also studied the interaction between aggregate and idiosyncratic risks. Atkeson and Phelan (1994) consider wage and employment idiosyncratic risks. In their model, agents can trade in risk-free bonds but not in state-contingent assets. The interest rate is endogenous. They argue that counter-cyclical policies could directly reduce income risks faced by each individuals or simply reduce the correlation in earnings by stabilising the unemployment rate. In the latter case, individual risks are unaffected. The only gain offered by stabilisation policies is to stabilise the interest rate: it avoids interest rate rises during downturns when more agents want to borrow to smooth consumption. Since interest rate fluctuations are small in US data, they find that welfare gains of such policies are extremely low. However, Beaudry and Pages (2001) emphasise that aggregate wage volatility could hide idiosyncratic risks that are caused by business cycle fluctuations. Eliminating aggregate fluctuations would also eliminate the idiosyncratic risk. Finding some middle ground, Santis (2007) builds a model with aggregate and independent idiosyncratic risks. Those two types of risks add-up. He argues that eliminating aggregate fluctuations might bring large welfare gains when agent already face substantial permanent idiosyncratic income shocks.

The literature described above focuses on the US. However, since Lucas (1987), it is clear that a crucial ingredient of the welfare cost of business cycles is consumption volatility. Countries with different levels of volatility would naturally experience different levels of welfare. Business cycles in emerging and developing economies display more volatility (see Agenor et al. (2000), Rand and Tarp (2002), Neumeyer and Perri (2005), Aguiar and Gopinath (2007) and Male (2011)). They experience sharper consumption fluctuations provoked by larger domestic and foreign shocks exacerbated by weaker resilience. Domestic shocks comprise volatile fiscal or monetary policies as well as shocks in the production sector such as extreme weather conditions. External shocks include sudden stops of capital inflows or abrupt changes in their terms of trade (e.g. Raddatz (2007) and Houssa et al. (2015)). In addition, their capacity to cope with different types of shocks is limited by lower international risk-sharing opportunities, less efficient stabilisations policies and heavier microeconomic regulations (Loayza et al. (2007)). Their financial sectors are incomplete and therefore do not offer enough instruments to adequately insure against all shocks and additionally tend to dry up in times of crisis. Heavier microeconomic regulations tend to hamper the reallocation of resources from low to high productive firms/sectors required to cope with shocks. These stylised facts indicate that the costs associated to business cycle fluctuations might be more important than the estimates provided for advanced countries. Pallage and Robe (2003) compared the costs of business cycles in advanced and developing countries in different environments (using different consumption processes and constrasting CRRA with EZ utility functions). They find that the cost of business cycle fluctuations ranges from 10 to 30 times their estimated values for the United States. Houssa (2013) estimates those costs for developed and developing countries with Bayesian methods accounting for parameter uncertainty. He finds that those costs are on average two to four times larger in developing countries, that they compare with a 1% increase in long-term growth for many developing countries and that oil producing and politically unstable countries would benefit the most from successful stabilising policies.

Reviewing these evidences shows that business cycles might be relatively more costly in developing and emerging countries for a variety of reason. First, as already studied in Pallage and Robe (2003) and Houssa (2013), excess consumption volatility translates into larger welfare costs. Second, since many households are excluded from financial markets in these economies, more agents should not be able to insure against idiosyncratic risks and to accumulate financial wealth. This could exacerbate the effects of aggregate volatility. Third, according to the New Keynesian tradition, inflation volatility (which is also larger in these countries) should also amplify the welfare cost of business cycles. These last two points motivate the measure of the costs of business cycles in a New-Keynesian DSGE model tailored to developing and emerging countries specificities. Structural models offer a natural laboratory for testing these effects and bring discipline to the exercise.

3.2.2 Stabilisation with monetary policy

Most advanced countries central banks recognise price stability as their primary objective. This is reflected in the gradual move, pioneered by New Zeeland, towards a formal inflation targeting framework. The benefits of price stability are well recognised. Among other advantages, price stability ensures transparency of the price mechanism, reduces the inflation risk premium, prevent arbitrary redistribution of resources and ease contract formation. In addition, through its impact on aggregate demand, monetary policy can also influence output and employment. Some central banks such as the US Federal Reserve therefore explicitly aim at supporting activity. Small open economies also often add exchange rate considerations to their policies which can be affected through the uncovered interest rate parity condition.

Following the wave of currency crisis during the 1994-2001 period, many emerging economies began to implement inflation targeting (Frankel (2011)). However, in practice, emerging and developing countries tend to respond to exchange rate fluctuations by "leaning against the wind", supporting the "fear of floating hypothesis" (e.g. Calvo and Reinhart (2002) and Mohanty and Klau (2004)). Even in countries officially operating under floating regimes, central banks often react to changes in the exchange rate. Their motivations include currency mismatches in balance sheets, the pass-through of exchange rate into prices, the impact of the exchange rate on net exports and large nominal or risk premium shocks, among others. Hausmann et al. (2001) find that countries with limited ability to borrow in domestic currency tend to tolerate less volatility in their exchange rate. In particular, the South African Reserve Bank (SARB) introduced a formal inflation targeting framework in 2000. It targets an average rate of consumer price inflation between 3 and 6%. Prior to this period, Ortiz and Sturzenegger (2007) estimate the Taylor rule in a NK-DSGE model. They find that the SARB responded consistently to inflation fluctuations and attached a larger weight on output, but a lower on the exchange rate when compared to other emerging economies. In a similar exercice, Peters (2016) finds that the inflation coefficient is positive and significant, while the output gap and exchange rate coefficients are also positive but insignificant.

Estimated DSGE models have become the standard toolkit for macroeconomic policy analysis. Much is known about solving these models (e.g. Uhlig (1995); Klein (2000) and Sims (2002)) and estimating (e.g. DeJong et al. (2000); Schorfheide (2000) and Otrok (2001)) as well as what modelling features are most relevant for understanding observed macroeconomic fluctuations in these economies (e.g. Smets and Wouters (2007) and Adolfson et al. (2007)). Those models have also been used to devise appropriate monetary (e.g. Gali and Monacelli (2005)) and fiscal policies (e.g. Ratto et al. (2009)). In fact, the central banks of most developed countries (e.g. the US Federal Reserve, the Bank of England, the European Central Bank) as well as policy institutions such as the International Monetary Fund all use estimated DSGE models for policy analysis. Monetary policy analysis in developing and emerging economies exploits similar models with few account for their specificities. However, some ingredients such as a large commodity sector (e.g. Mendoza (1995)), imported foreign intermediate inputs (e.g. Kose (2002)) and non-Ricardian households (e.g. Medina and Soto (2007)) have been proposed. Other considerations beyond the scope of this paper but specific to developing and emerging countries relate to the volatility of food prices and to the management of volatile aid flows.[8,9]

[8]Anand et al. (2015) study the optimal inflation measure that a developing country central bank should target. They build a three sectors model: an informal food sector, a formal non-traded good sector and a formal traded-good sector (capturing the role of commodities). In a context of credit-constrained households primarily working in the food sector and spending a large portion of their income in food, they find that it is preferable to target headline inflation than core inflation. The optimal index includes food but excludes imported goods.

[9]Adam et al. (2009) build a two sectors DSGE model with sticky prices in the non-traded sector, currency substitution and volatile aid flows. Monetary policy operates through foreign exchange reserves management and government securities transactions with the private sector. When increased aid flows translate into lower domestic financing requirements (i.e. when all aid is not immediately spent), the decrease in domestic money supply encourages domestic households to substitute foreign currency into domestic currency. This generate an appreciation which has destabilising impacts for both prices and output. These can be mitigated with net foreign assets accumulation at the central bank as a response to appreciation.

An early literature, mostly applied to the US, studied optimal monetary policy in simple models with price rigidities (e.g. Ireland (1997), Rotemberg and Woodford (1997, 1999) and Clarida et al. (1999)). These authors show that the Fed implicit inflation targeting framework adopted since the Volcker era successfully insulated the US economy from demand shocks. This literature argues that central bank (credible) commitment to respond to inflation is enough for monetary policy to be efficient as long as the private sector is forward-looking. However, these papers further ague that the Fed leaning against the wind policy was not optimal due to the identification of large supply disturbances. Optimal policy response to supply shocks requires the Fed to accommodate the change in output in order to stabilise prices. Barlevy (2004) supports the view that the benefit from stabilisation policies depends on the type of shocks responsible for macroeconomic fluctuations. Monetary and fiscal policies are well suited in order to stabilise fluctuations generated by demand (or nominal) shocks, but not in the case of supply (or real) shocks. He claims that the gains from post-war stabilisation policies in the US were substantial but that the benefits from further stabilisation could be small. However, in the absence of appropriate stabilisation policies, the welfare cost of business cycles would be much larger. Therefore, stabilisation policies should remain a priority. The literature has built on those models by gradually increasing their complexity to gain in realism. Schmitt-Grohe and Uribe (2007) study optimal simple monetary and fiscal rules in a NK-DSGE model. The model includes price stickiness, capital accumulation and demand for money origination from firms' working capital and households' cash in advance constraints. They calibrate the model on US data and compare the welfare costs of alternative Taylor rules coefficients (with interest rate smoothing and inflation and output responses) relative to the time-invariant stochastic equilibrium allocation associated with the Ramsey policy. They find that welfare gains from increasing the value of the inflation coefficient beyond the Taylor principle and from interest rate smoothing are extremely low. In addition, responding to output generates a large welfare loss. The conclusion reached by this first body of literature summarises as follow: with perfect financial markets and forward-looking agents, inflation targeting is the optimal monetary policy, but the extra gains from very aggressive inflation responses could be very low.

Erceg et al. (2000) extend the baseline NK-DSGE model to consider price and wage stickiness. The volatility in aggregate wage inflation causes dispersion in individual wages, which generates inefficient fluctuations in individual hours worked. In this context, it is impossible for the central bank to stabilise the output-gap and price and wage inflation rates at the same time. Strict inflation targeting becomes inefficient. Benigno and Woodford (2005) show that these results hold in the case of a distorted steady-state. However, Schmitt-Grohé and Uribe (2006) build a medium scale NK-DSGE model (including both capital and sticky wages) and find that the central bank should place more emphasis on price than on wage stability. Building on the Mortensen and Pissarides (1994) search and matching model, Gertler and Trigari (2009) introduce staggered wage bargaining in an otherwise standard NK-DSGE model. At every petriod, some firms and workers bargain over wages while other cannot re-adjust their wages. In this context, Thomas (2008) shows that pure inflation targeting is inefficient. Indeed, as real wages can deviate from their optimal level, the central bank can use inflation to adjust real wages and therefore faces a trade-off between price and employment stability. Overall, these studies suggest that price stability should remain the central concern of monetary policy but that it could be complemented with wage stabilisation objectives.

In small open economies, the CPI is affected by domestic and imported goods prices. The latter depends on the exchange rate. The literature compares the effects of stabilisation policies responding to each components of the CPI with rules focusing on the domestic price index. Moreover, it assesses the impact of different exchange rate rules such as a pure float, a managed float and a peg. Gali and Monacelli (2005) develop a SOE version of the canonical NK-DSGE model. They find that a Taylor rule based on domestic inflation is preferable in term of welfare to a similar Taylor rule based on CPI and to an exchange rate peg. The optimal rule implies *perfect* stabilisation of the domestic price index. Kollmann (2002) considers monopolistic distortions and finds that the optimal rule consists of a *strict* response to the domestic price index which tolerates large fluctuation in the exchange rate and minimal fluctuations in the price index. In addition, Leitemo and Soderstrom (2005) show that the gains of integrating the exchange rate in the Taylor rule are generally low using a variety of models. However, Engel (2011) brings the issue of currency misalignment (the fact that prices can differ between countries when compared in the same currency) in an otherwise simple framework. Violations of the law of one price occur due to local-currency pricing and are inefficient. If prices are sticky in the importer's currency, then targeting CPI delivers the optimal policy. In some developing and emerging countries, choosing the right price target is particularly important because imported goods prices display stronger fluctuations driven by volatile exchange rates. Devereux et al. (2006) construct a two sectors SOE model representing an emerging economy. They introduce imperfect exchange rate pass-through and lending constraints on external credit for investment (labelled in foreign currency) in an otherwise basic NK model. They find that the optimal monetary rule depends on the degree of exchange rate pass-through. In a high pass-through environment, the central bank should target the domestic non-traded good price index, while in the low pass-through case, it is preferable to target the consumer price index. Hove et al. (2015) study the optimal monetary policy response to exogenous term of trade shocks in a small scale SOE-DSGE model with tradables and non-tradables. Firms in the traded sector operate under perfect competition: there is no incomplete exchange rate pass-through. They calibrate their model to the South African economy and approximate welfare using loss functions with different weights on the variance of inflation, output-gap, interest rates and exchange rates. They find that a CPI inflation targeting performs better than non-traded (domestic) inflation targeting. In addition, they find that exchange rate targeting has a detrimental aggregate welfare effect. This body of research shows that the choice of the optimal target - CPI vs a domestic price index

- crucially depends on the exchange rate pass-through and to the exposure to term of trade shocks. Moreover, pure-floats usually beat managed-floats and pegs in these studies.

The literature has also recently advocated for the inclusion of different types of agents in a context of imperfect financial markets (e.g. Bilbiie (2008), Nisticò (2016), Cúrdia and Woodford (2016) and Bilbiie and Ragot (2017)). These papers motivations include the impact of imperfect financial markets on the interest rate transmission channel; the role of monetary policy on financial stability; and the link between monetary policy and inequality. In developing and emerging markets, many households are excluded from the asset markets. The literature has recently started to study this issue. Two studies applied to emerging countries are presented here in details. Iyer (2016) considers two types of households in an otherwise standard SOE-DSGE model and finds that exchange rate targeting stabilises the import-content of consumption for financially excluded households. Although inflation targeting remains the optimal monetary policy when financial inclusion is sufficiently high, exchange rate targeting is desirable in low financial inclusion environments. Prasad and Zhang (2015) include heterogeneous households and incomplete financial markets in a two-sector (tradable and non-tradeable goods) SOE-DSGE model. Prices are sticky in the non-tradable sector and flexible in the tradable sector. Workers in the non-traded sector are hand to mouth consumers. They calibrate the model to an emerging economy and also find that exchange rate targeting has a detrimental aggregate welfare impact. However, when a positive productivity shock hits the home tradeable goods sector (which implies an appreciation), households in this sector fare better under exchange rate management in the short run. These two studies are closely related to the present paper. They both consider imperfect financial markets in emerging economies. However, they differ in the sense that households inside each group remain homogeneous.

The benefits from inflation targeting are relatively well established, both for advanced and emerging economies. However, these results were expected, in the sense that prices and wages fluctuations represent the largest part of the welfare costs of business cycles in these models. Indeed, a combination of relatively smooth aggregate consumption fluctuations and perfect financial markets generate relatively low costs of consumption fluctuations as in Lucas (1987) experiment for the US. These fluctuations are larger in emerging markets, but the extra volatility is also present in the price and wage indexes, thereby leading to similar optimal policies. The choice of the optimal price index remains debated. CPI is more likely to be favoured when the exchange rate pass-through is weak and when term of trade shocks are large. Usually, output and exchange rate management do not improve welfare. In the present paper, business cycles fluctuations interact with idiosyncratic risks and imperfect assets markets. They could generate new trade-offs for monetary policy.

3.3 Background on the South African labour market

This section describes the South African labour market. Its objective is to isolate the empirically relevant features required to build the model presented in the next section. A striking characteristic of the South African labour market is its very large unemployment rate which fluctuated around 25% over the post-Apartheid period. Moreover, almost 65% of the unemployed have been without a job for over a year and many of them have never worked (Banerjee et al. (2008)). The literature has proposed a variety of potential explanations, some of which are based on the fact that wages seem disconnected to labour productivity and unemployment rates (e.g. Banerjee et al. (2008) and Klein (2012)).[10] Considering the key role played by the labour market in this paper, this section is devoted to the description of labour market legislations covering collective bargaining and the provision of unemployment benefits. In addition, the impact of labour unions on the performance of the South African labour market is discussed.

Legislative framework The most relevant regulations consist in the Labour Relation Act (LRA) of 1995, the Basic Conditions of Employment Act (BCEA) of 1997 and the amended Unemployment Insurance Act (UIA) of 2001. The LRA defines the rights of trade unions and regulates collective bargaining and the BCEA defines the basic conditions of employment. Collective bargaining on wages and employment conditions can take different forms. Inside the statutory system, trade unions and employers' organisations meet in Bargaining Councils or in Statutory Councils. Outside the statutory system, negotiations can take place at the firm level or in centralised bargaining forums. Bargaining Councils are the central pillar of collective bargaining and they cover one third of the formal sector workforce (Bhorat et al. (2012)). They are formed by trade unions and employers' organisations in a specific sector and area on a voluntary basis on the condition that they are sufficiently representative of firms and unions. The agreements reached by Bargaining Councils apply to all their members and can be extended to other non parties in the same sector and area. In practice, Bargaining Councils range from small local to large national organisations but they tend to merge into larger organisations. Other forms of collective bargaining are present in some specific sectors. In the mining sector, firms and unions bargain in centralised forums (gold and coal) or at the plant-level (platinum and diamond). The amended UIA establishes an unemployment insurance fund. Employers and employees contribute to the fund. The unemployed receive insurance benefits based on their wage over a period function of their employment duration (and caped at 34 weeks). The replacement rate varies between 38 and 60% of income with a lower rate for higher income levels. Those who have never worked and those occupied in the informal or public sectors are

[10] Other reasons advanced to explain the high unemployment rate in South Africa are skill mismatches between labour supply and demand; a growing working age population; large reservation wages; concentration and regulations in the product market preventing small firms entry as well as a weak entrepreneurial culture inherited from the Apartheid period.

excluded from this scheme. The claiming rate (defined as the claimant to contributors ratio) is therefore relatively modest (about 6% in 2010 compared to the unemployment rate of about 25% in the same period). For more details on the institutional framework governing collective bargaing and the unemployment insurance scheme, the interested reader is refereed to Godfrey et al. (2007), Bhorat et al. (2009) and Bhorat et al. (2013).

Labour unions Labour unions are important in South Africa and inherited from the role played by labour movements during the Apartheid period in the transition to democracy. Labour unions are organised in regional or national federations. The largest is the Congress of South African Trade Unions (COSATU) which covers more than 2 millions members. In addition to their influence in collective bargaining, labour unions also play an important political role. The COSATU is part of the tripartite alliance with the African National Congress and the South African Communist Party. Union density (expressed as a fraction of unionised workers to the total word force) is relatively high in South Africa (37.5% compared to 30% on average in OECD countries), especially in the mining (80%) and public (70%) sectors (Bhorat et al. (2014)). Unions are believed to contribute to the poor performance of the South African labour market for various reasons. First, they reinforce an insider/outsider dynamic. Indeed, job security is associated to union affiliation and job finding rates depend on past experience and networks (Fedderke (2012) and Anand et al. (2016)). Moreover, affiliated workers are generally older, more educated and are more likely to hold permanent employment positions with written labour contracts (Bhorat et al. (2012)). Second, labour unions and the Bargaining Councils framework allow workers to extract a wage premium. Controlling for union membership endogeneity, Bhorat et al. (2012) estimate that unionised workers covered by Bargaining Councils agreements earn a total premium of 16.4% over their non-unionised and uncovered counterparts. The increase in labour costs could raise unemployment. Indeed, Magruder (2012) finds that Bargaining Councils have adverse effects on employment creation, especially in small firms and von Fintel (2017) shows that union density is correlated to wages and has a negative impact on labour demand and employment. Third, various rigidities generate sticky non-clearing wages (Fedderke (2012)). In particular, wages in large firms with a high concentration of unionised workers are slow to adjust to unemployment rates (von Fintel (2016)). For a detailed description of the state of labour unions in South Africa, see Bhorat et al. (2014) and Armstrong and Steenkamp (2008).

3.4 Model

The model consists of two blocks: a domestic small open emerging economy and the rest of the world. The domestic block extends the SOE-DSGE model proposed by Adolfson et al. (2007). It incorporates key emerging countries structural characteristics that are particularly relevant to the South African economy as described in Houssa et al. (forthcoming). These include: *i)* two categories of households to capture key differences between financially included and excluded households and *ii)* two different types of goods to account for the specific role of commodities in exports. In addition, there are two different versions of the model that differ according to the functioning of the labour market. The working of the enlarged model is summarized as follows.

The economy is populated by two types of households: optimising and rule of thumbs. Households derive utility from consumption of a composite good (consisting of both domestic and imported goods) and leisure. Consumption preferences are subject to habit formation. Optimising households accumulate financial wealth in the form of risk free domestic and foreign bonds. They build capital which is sector specific and subject to investment adjustment costs. The investment basket is a composite of domestic and imported inputs. Rule of thumb households are excluded from financial and capital markets and unable to accumulate wealth. They consume their entire income in each period. Contrary to optimising households, they have no access to state contingent claims and therefore cannot insure against idiosyncratic risks. Income heterogeneity thus translates into consumption heterogeneity with potentially important implications on individual consumption fluctuations and aggregate welfare.

There are two sorts of good: commodities and secondary products. Commodity goods are homogeneous and produced under perfect competition. Commodity producers combine capital, labour and land and sell their products in the world market. Secondary goods are produced in a perfectly competitive environment (but distributed by firms enjoying market power). Secondary good producers combine capital and labour to produce an undifferentiated intermediate goods. Distributors operate in three markets: domestic, import and export. Domestic distributors turn secondary goods into consumption and investment goods sold to households. Importing distributors turn foreign secondary goods into foreign consumption and investment goods sold to domestic households. Exporting distributors sell domestic secondary goods to foreign households. The distribution sector is composed of intermediate and aggregating firms. Each intermediate distributor is a monopoly supplier of its specific product and follows a price adjustment rule à-la Calvo (1983). Nominal rigidities in importing and exporting sectors allow for short-run incomplete exchange rate pass-through to both import and export prices[11].

There are two different (and independent) versions of the labour market. The first version of the model follows Erceg et al. (2000) which indroduce wage rigidities à-la Calvo (EHL version). Optimising households supply monopolistically a differentiated labour services and set they own hourly wage whenever they receive a random signal. Rule of thumb households mimic their optimising counterpart whenever they are allowed to reset their wages. All other workers simply index their wages. The second version takes inspiration from Gertler and Tri-

[11]Compared to the traded/non traded good literature, this framework offers more flexibility by incorporating one non traded good: the final good sold by domestic distributors; and *two* traded goods: commodities (produced in a perfectly competitive environment) and final goods (sold by importing/exporting distributors). The traded and non traded final goods have different Phillips Curves.

gari (2009) and Thomas (2008). They propose search and matching frictions in the labour market with staggered wage bargaining (GTT version). Frictions generate unemployment and firm post vacancies to attract unemployed workers. At every period, a fraction of optimising workers regroup in unions and bargain with the firms over wages. An identical fraction of rule of thumb workers takes the outcome of this bargain as given. All other workers index their wages.

The government collects pay-roll, labour income, consumption and capital gain taxes. It follows a simple rule that determines its level of public consumption. The central bank sets the interest rate which depends on inflation, output growth and the change in exchange rate.

The rest of the world is a closed version of the domestic economy based on Smets and Wouters (2007). It is extended with a commodity sector. Commodity prices are endogenously determined in the foreign economy bloc assuming that the small open domestic economy has no impact on commodity prices. The following subsections describe the model in details.

3.4.1 Households

The economy is populated by two types of agents: optimising and rule of thumb households. Any i^{th} optimising household (or any l^{th} rule of thumb household) attains utility from consumption $C_{i,t}$ and dis-utility from hours worked $H_{i,t}$ at time t. Its life-time utility is given by

$$\mathbb{W}_{i,t} = \mathrm{E}_0^i \sum_{t=0}^{\infty} \beta^t U_{i,t} = \mathrm{E}_0^i \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_{i,t}/(\bar{C}_{t-1})^b\right)^{1-\sigma_c} - 1}{1-\sigma_c} - A_h N_{i,t} \frac{(H_{i,t})^{1+\sigma_h}}{1+\sigma_h} \right], \tag{3.4.1}$$

where E is the expectation operator and β is the discount factor. The term $N_{i,t}$ represent employement and is equal to one when the agent is employed and zero otherwise. The parameters σ_c and σ_h denote the inverse of the inter-temporal elasticity of substitution for consumption and the inverse of the elasticity of work effort, respectively; A_h is the relative importances of labour in the utility; b an external multiplicative habits parameter[12] and $\bar{C}_{t-1}$ is the lagged average value of consumption of a reference group.

The composite consumption basket $C_{i,t}$ for any household i is given by the CES index of domestic and imported goods

$$C_{i,t} = \left[(1-\omega_c)^{1/\eta_c} (C_{i,t}^d)^{(\eta_c-1)/\eta_c} + (\varepsilon_{\omega,t}\omega_c)^{1/\eta_c} (C_{i,t}^m)^{(\eta_c-1)/\eta_c} \right]^{\eta_c/(\eta_c-1)}, \tag{3.4.2}$$

where C_t^d and C_t^m denote consumption of the domestic and imported good, respectively, ω_c is the steady-state share of imports in consumption, $\varepsilon_{\omega,t}$ a shock to the home bias and η_c is the

[12] Multiplicative habits were introduced by Abel (1990) and Gali (1994).

elasticity of substitution between domestic and foreign consumption goods.

Financially included and optimising households

There is a continuum of optimising households (OHs) indexed by $i \in (0,1)$ with access to financial and capital markets. The representative agent maximizes the inter-temporal utility by choosing her consumption and investment levels, as well as domestic and foreign bond holdings.[13] For any given period t, OHs face the same budget constraint which is given, in nominal terms, by

$$\begin{aligned} & B_{i,t+1} + S_t B^*_{i,t+1} + (1+\tau^c) P^c_t C_{i,t} + P^i_t \left(I^p_{i,t} + I^f_{i,t} \right) \\ = {} & (1-\tau^k) \left(R^{k,p}_t K^p_{i,t} + R^{k,f}_t K^f_{i,t} \right) + \frac{1-\tau^y}{1+\tau^w} \overline{W}_{i,t} N_{i,t} + (1-N_{i,t}) \varpi_t \\ & + TR_{i,t} + SCS_{i,t} + \varepsilon_{b,t-1} R_{t-1} B_{i,t} + \varepsilon_{b,t-1} R^*_{t-1} \Phi(A_{t-1}, \tilde{\phi}_{t-1}) S_t B^*_{i,t} \end{aligned} \tag{3.4.3}$$

where the subscript i indicator denotes the household's choice variables, whereas the variables, without the subscript, are the economy-wide aggregates. The variable $\overline{W}_{i,t} = W_{i,t} H_{i,t}$ represents the period t labour income and $W_{i,t}$ is the hourly wage rate.[14] The term ϖ_t captures unemployment benefits (set to a fraction of the average labour income in the economy). B_t denotes the value of nominal domestic bonds, S_t is the nominal exchange rate representing the amount of local currency per unit of foreign currency and B^*_t the value of foreign bonds (in foreign currency). R_t and R^*_t are the domestic and foreign gross risk-free interest rates controlled by the monetary authority, respectively. The exogenous process $\varepsilon_{b,t}$ creates a wedge between policy and private interest rates. P^c_t is the consumer price index and P^i_t the investment good price index. Households invest I^f_t in private capital K^f_t used in the secondary sector and I^p_t in private capital K^p_t used in the primary sector. $R^{k,p}_t$ and $R^{k,f}_t$ are the returns of capital in the primary and final sectors, respectively. The term $TR_{i,t}$ represents transfers from the government and the firms, $SCS_{i,t}$ is the household's net cash income from participating in state contingent securities at time t. The government collects taxes on consumption τ^c, pay-roll τ^w, labour-income τ^y and capital-income τ^k.

Country risk premium In equation (3.4.3), the term $R^*_{t-1}\Phi(A_{t-1}, \tilde{\phi}_{t-1})$ represents the risk-adjusted gross interest rate paid by foreign bonds (in foreign currency). The function $\Phi(.)$ captures the country risk premium function of the real aggregate net foreign asset position

[13]The domestic financial markets are assumed to be complete, thus each financially included household can insure against any type of idiosyncratic risk through the purchase of the appropriate portfolio of state contingent securities. This prevents the frictions from causing these households to become heterogeneous, so the representative agent framework is still valid for this type of households.

[14]In the EHL model, households set their hourly wage rate $W_{i,t}$ while in the GTT version firms and workers bargain over the period - monthly in their paper or quarterly in this paper - wage $\overline{W}_{i,t}$.

$A_t \equiv \frac{S_t B^*_{t+1}}{P_t}$ and a time varying shock to the risk premium $\tilde{\phi}_t$.[15]

This function illustrates the imperfect integration in the international financial markets of the domestic economy and induces stationarity of the model.[16] Therefore, domestic households are charged a premium over the (exogenous) foreign interest rate R^*_t if the domestic economy is a net borrower ($B^*_t < 0$), and receive a lower remuneration on their savings if the domestic economy is a net lender ($B^*_t > 0$).

Capital accumulation Capital and investment are sector specific. The capital accumulation rule is subject to investment adjustment costs and follows

$$K^q_{t+1} = (1-\delta)K^q_t + \Upsilon_t F(I^q_t,\, I^q_{t-1}) \; , \tag{3.4.4}$$

where $q \in (p,f)$ represents the primary or secondary sector and δ is the depreciation rate. The variable Υ_t is a stationary investment-specific technology shock common to both sectors and $F(I_t, I_{t-1})$ represents a function which turns investment into physical capital. The $F(I_t, I_{t-1})$ function is specified following Christiano et al. (2005) as:

$$F(I_t,\, I_{t-1}) = (1 - \tilde{S}(I_t/I_{t-1}))I_t \; , \tag{3.4.5}$$

where the function $\tilde{S}(I_t/I_{t-1})$ is defined by

$$\tilde{S}(I_t/I_{t-1}) = \phi^i_3 \left\{ exp\left(\frac{I_t}{I_{t-1}} - 1\right) + exp\left(-\frac{I_t}{I_{t-1}} + 1\right) - 2 \right\}, \tag{3.4.6}$$

with $\tilde{S}(1) = \tilde{S}'(1) = 0$ and $\tilde{S}''(1) \equiv \tilde{S}'' = 2\phi^i_3 > 0$.

Investment basket The investment good (I^q) with $q \in (p,f)$ is given by a CES aggregate of domestic ($I^{d,q}_t$) and imported investment inputs ($I^{m,q}_t$)

$$I^q_t = \left[(1-\omega_i)^{1/\eta_i} (I^{d,q}_t)^{(\eta_i - 1)/\eta_i} + (\varepsilon_{\omega,t}\omega_i)^{1/\eta_i} \, (I^{m,q}_t)^{(\eta_i - 1)/\eta_i} \right]^{\eta_i/(\eta_i - 1)}, \tag{3.4.7}$$

where ω_i is the steady-state share of imports in investment and η_i is the elasticity of substitution between domestic and imported investment goods.

[15]The function $\Phi(A_t, \tilde{\phi}_t) = \exp(-\tilde{\phi}_A(A_t - \overline{A}) + \tilde{\phi}_t)$ is strictly decreasing in A_t and satisfies $\Phi(\bar{A}, 0) = 1$. In particular, Adolfson et al. (2007) set $\bar{A} = 0$.

[16]see Schmitt-Grohe and Uribe (2003).

Rule of thumb households

There is a continuum of rule of thumb households (ROTHs) of mass 1 indexed by $l \in (0,1)$ with preferences given by (3.4.1).[17] These households do not have access to financial and capital markets. Financial exclusion has two components. First, they are excluded from insurance markets and therefore unable to edge against labour market idiosyncratic risks. Second, bonds markets exclusion - together with capital markets exclusion - imply that they are unable to transfer wealth inter-temporally. They consequently consume their entire labour income in every period. Their budget constraint is given by

$$(1+\tau^c)P_t^c C_{l,t} = \frac{1-\tau^y}{1+\tau^w}\overline{W}_{l,t}N_{l,t} + \left(1-N_{l,t}\right)\varpi_t \ , \tag{3.4.8}$$

where $\overline{W}_{l,t} = W_{l,t}H_{l,t}$. This specification allows for heterogeneity in households wages and introduces unemployment benefits ϖ_t.

3.4.2 Firms

There are two categories of goods in this model: primary commodities and secondary products.

Commodity sector

Primary commodities are produced in the domestic and foreign blocks. While the rest of the model section focuses exclusively on the domestic economy, this subsection also describes the commodity market in the foreign economy in order to highlight how commodity prices are endogenously determined in the world market.

Domestic commodity producers The commodity good is produced under perfect competition in the domestic economy. Firms combine capital and labour to produce a commodity input Y_t^p and sell their production on the world market. The production function for primary producers is given by

$$Y_{j,t}^p = Y_0^p \varepsilon_t^p \left(\frac{\varepsilon_{k,t}K_{j,t}^p}{K_0^p}\right)^{\alpha_p} \left(\frac{L_{j,t}^p}{L_0^p}\right)^{(1-\alpha_p-\beta_p)} , \tag{3.4.9}$$

where the terms Y_0^p, K_0^p and L_0^p are normalising constants and only represent choices of units. The term ε_t^p is a pure commodity supply shock; $\varepsilon_{k,t}$ is a capital augmenting technology shock common to the primary and secondary sectors, K_t^p is capital used in the mining sector, $L_{j,t}^p =$

[17] Rule of thumb households were introduced in Coenen and Straub (2005), Erceg et al. (2006) and Galí et al. (2007). These types of households have been introduced in DSGE models applied to developing countries by Medina and Soto (2007), Céspedes et al. (2012) and Prasad and Zhang (2015).

$N^p_{j,t}H^p_{j,t}$ is the amount of labour equal to the number of employees multiplied by hours worked per employee. The stock of land is fixed and set to one for simplicity. The income shares of capital and land are given by α_p and β_p, respectively. The commodity sector captures the impact of world commodity price on the domestic economy.[18]

Foreign commodity market World commodity price P_t^{*p} is determined endogenously through the confrontation of the foreign supply and foreign demand for commodities. Foreign commodity supply is modelled as an exogenous AR(1) process

$$Y_t^{p*} = \rho_{p*} Y_{t-1}^{p*} + \varepsilon^*_{p,t}, \tag{3.4.10}$$

where $\varepsilon^*_{p,t}$ is the foreign commodity supply shock which is assumed to be a MA process.

The foreign demand for commodity is determined by the foreign secondary good sector where it served as inputs. Foreign firms combine capital, labour and commodities to produce a secondary foreign goods:

$$Y_t^* = Y_0^* \left[\beta^* \left(\frac{Y_t^{p*}}{Y_0^{p*}} \right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} + (1-\beta^*) \left(\left(\frac{\varepsilon^*_{k,t} K_t^*}{K_0^*} \right)^{\alpha^*} \left(\frac{L_t^*}{L_0^*} \right)^{(1-\alpha^*)} \right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} \right]^{\frac{\sigma_p^*}{\sigma_p^*-1}}, \tag{3.4.11}$$

where where L_t^* is labour, K_t^* is capital and $\varepsilon^*_{k,t}$ is a capital efficiency shock. The terms Y_0^*, Y_0^{p*} and K_0^* are normalizing constants; β^* is the (income) share of commodities in foreign secondary goods sector; $(1-\beta^*)\alpha^*$ is the income share of capital and σ_p^* is the elasticity of substitution between commodities and the other production factors. Equation (3.4.11) shows how foreign (supply or demand) shocks could be transmitted to the domestic economy through commodity prices. Typically, whenever foreign firms want to increase production, demand for commodity increases which is transmitted to commodity prices. The elasticity σ_p^* is a key parameter that determines the strength of commodity price responses to changes in foreign demand for commodity.

Secondary sector

Domestic and foreign secondary goods are used for domestic and foreign consumption and investment as imperfect substitutes. Imperfect competition is introduced in three steeps: *i)* production of an un-differentiated secondary good, *ii)* its differentiation with brand-naming

[18] Previous studies include for example Medina and Soto (2007) and Céspedes et al. (2012). This model departs from those works by assuming that commodity production is not exogenously given and require some inputs. With this respect, this specification is very similar to Kose (2002) who studies primary sector price shocks in a RBC model. It also relates to Hove et al. (2015) which examine monetary policy responses to commodity price fluctuations in a small calibrated NK DSGE model.

technology and finally *iii)* its aggregation into a consumption or investment good. Step one is performed by secondary good producers while steps two and three depends on intermediate and final distributors operating in the domestic, import and export markets.

Secondary good producers The secondary good is produced under perfect competition. Firms use capital K^f and hire labour L^f to produce an undifferentiated secondary good denoted Y^f. The production function for the secondary good is given by

$$Y_{j,t}^f = Y_0^f \left(\frac{\varepsilon_{k,t} K_{j,t}^f}{K_0^f} \right)^{\alpha_f} \left(\frac{L_{j,t}^f}{L_0^f} \right)^{(1-\alpha_f)}, \tag{3.4.12}$$

where the terms Y_0^f, K_0^f and L_0^f are normalising constants and only represent choices of units. $L_{j,t}^f = N_{j,t}^f H_{j,t}^f$. The term $\varepsilon_{k,t}$ represents a capital augmenting technology shock common to the primary and secondary sectors and α_f is the capital income share.

Domestic distributors There are two types of domestic distributors: intermediate and final. There is a continuum of intermediate distributors, indexed by $j \in [0,1]$. Each intermediate distributor buys a homogeneous secondary good Y^f; turns it into a differentiated intermediate good (using a brand naming technology) and then sells it to a final distributor at price $P_{j,t}$. Every intermediate distributor is assumed to be a price taker in the secondary good markets (it purchases secondary goods at their marginal costs) and a monopoly supplier of its own variety (it sets its own price).

The intermediate distributor follows a price adjustment rule à-la Calvo (1983). Every period t, with probability $(1-\xi_d)$, any intermediate distributor j is allowed to re-optimize its price by choosing the optimal price P_t^{new}.[19] With probability ξ_d, it cannot re-optimize, and it simply indexes its price for period $t+1$ according to the following rule:

$$P_{j,t+1} = (\pi_t)^{\kappa_d} (\varepsilon_{\pi,t+1} \overline{\pi})^{1-\kappa_d} P_{j,t},$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is last period's inflation, $\overline{\pi}$ is the inflation target; κ_d is an indexation parameter and $\varepsilon_{\pi,t+1}$ is a shock to the price indexation process.

The final distributor is an aggregator which uses a continuum of differentiated intermediate goods to produce the final homogeneous good, which is then used for consumption and investment by domestic households and sold at price P_t. The final distributor is assumed to have the following CES production function:

[19] Since all distributors allowed to reset their prices are virtually identical and will always choose the same price the index j is dropped to simplify the notation.

$$J_t^d = \left[\int_0^1 \left(J_{j,t}^d \right)^{\frac{\varepsilon_d - 1}{\varepsilon_d}} dj \right]^{\frac{\varepsilon_d}{\varepsilon_d - 1}}, \ 1 < \varepsilon_d, \tag{3.4.13}$$

where $J \in (C, I)$ refers to the consumption or investment good and ε_d is the elasticity of substitution between intermediate inputs. Consequently, the relative demand for input type j is given by

$$J_{j,t}^d = \left(\frac{P_{j,t}}{P_t} \right)^{-\varepsilon_d} J_t^d \tag{3.4.14}$$

where P_t is the price index defined by

$$P_t = \left[\int_0^1 P_{j,t}^{1-\varepsilon_d} di \right]^{\frac{1}{1-\varepsilon_d}} \tag{3.4.15}$$

Exporting distributors The intermediate exporting firm buys a homogeneous domestic good Y^f to domestic secondary producers, turns them into a type specific differentiated good using a brand naming technology and then sells it in the foreign market to an aggregator at price $P_{j,t}^x$ expressed in foreign currency.

Domestic intermediate exporting firms follow a Calvo price setting rule and can optimally change their price only when they receive a random signal. In any period t, each exporting firm has a probability $(1 - \xi_x)$ to re-optimize its price by choosing $P_{new,t}^x$. With probability ξ_x the importing firm cannot re-optimize at time t and, instead, it indexes its price according to the following scheme: $P_{j,t+1}^x = (\pi_t^x)^{\kappa_x} (\overline{\pi})^{1-\kappa_x} P_{j,t}^x$ where $\pi_t^x = \frac{P_t^x}{P_{t-1}^x}$. This foreign currency price stickiness assumption implies short run incomplete exchange rate pass-through to the export price.

The aggregator produces final exported consumption and investment goods sold at price P_t^x to foreign households. The final, composite, exported good aggregates a continuum of j differentiated exported goods, each supplied by a different firm, according to

$$X_t^f = \left[\int_0^l (\tilde{X}_{j,t})^{\frac{\varepsilon_x - 1}{\varepsilon_x}} dj \right]^{\frac{\varepsilon_x}{\varepsilon_x - 1}}, \ 1 < \varepsilon_x. \tag{3.4.16}$$

where ε_x is the elasticity of substitution between intermediate inputs.

Assuming that aggregate foreign consumption and investment follow CES functions, foreign demand for the aggregate final exported good is defined by

$$X_t^f = \left(\frac{P_t^x}{P_t^*} \right)^{-\eta_f} X_t^*, \tag{3.4.17}$$

where P_t^* is the price of the foreign good in foreign currency, P_t^x is the export price (denominated in export market currency) and X_t^* is foreign demand function of foreign consumption and investment. The coefficient η_f is the foreign elasticity of substitution between foreign and domestic goods and allows for short run deviations from the law of one price.

Importing distributors The (foreign owned) intermediate importing firm buys a homogeneous foreign good in the world market. It turns it into a type specific good using a differentiating technology (brand naming) and then sells it in the domestic market to an aggregator at price $P_{j,t}^m$.

Foreign intermediate importing firms follow a Calvo price setting rule and can optimally change their price only when they receive a random signal. In any period t, each importing firm has a probability $(1-\xi_m)$ to re-optimize its price by choosing $P_{new,t}^m$[20]. With probability ξ_m the importing firm cannot reoptimize at time t and, instead, it indexes its price according to the following scheme: $P_{j,t+1}^m = (\pi_t^m)^{\kappa_m}(\overline{\pi})^{1-\kappa_m}P_{j,t}^m$ where $\pi_t^m = \frac{P_t^m}{P_{t-1}^m}$. This local currency price stickiness assumption implies incomplete exchange rate pass-through to the consumption and investment import prices.

The aggregator produces final imported consumption and investment goods sold at price P_t^m to households.[21] The final imported consumption and investment goods are aggregated using a continuum of j differentiated imported goods. Each are supplied according to

$$J_t^m = \left[\int_0^l (J_{j,t}^m)^{\frac{\varepsilon_m - 1}{\varepsilon_m}} dj\right]^{\frac{\varepsilon_m}{\varepsilon_m - 1}}, \ 1 < \varepsilon_m, \tag{3.4.18}$$

where $J \in (C, I)$ and ε_m is the elasticity of substitution between intermediates in the imported consumption and investment sectors.

3.4.3 Labour market

This paper considers two alternative mecanisms generating sticky wages and labour income dispersion. The first model (EHL) introduces monopolistic competition and staggered nominal contracts in the labour market following Erceg et al. (2000). The second one (GTT) consists in search and matching frictions in the labour market with staggered nominal wage bargaining presented in Gertler and Trigari (2009) and Thomas (2008). The rest of the assumptions described in preceding and following subsections hold for both models.

[20]All importing firms that are allowed to re-optimize their price, in a given period, will choose the same price, therefore it is not necessary to use a firm index

[21]This assumption departs from Adolfson et al. (2007) by assuming that the imported good price is the same for both investment and consumption. In addition, importing firms buy the foreign input at their marginal costs to foreign producers (instead of foreign distributors).

Monopolistic competition and staggered wage contracts

In this model, there are no real rigidities on the labour market. All workers are employed and all Ns simplify to one in the households and firms sections. Optimising households supply monopolistically a differentiated labour service and set they own hourly wages whenever they receive a random signal. Rule of thumb households mimic their optimising counterpart whenever they are allowed to reset their wages. All other workers simply index their wages.

Wage setting Every OH i (and every ROTH j) is a monopoly supplier of a differentiated labour service and sets its own hourly wage $W_{i,t}$ with an adjustment rule à-la Calvo. Households have a probability $(1-\xi_w)$ to be allowed to re-set their wages. OHs set their wage to maximise their inter-temporal utility. ROTHs mimic OHs by setting the same wage[22]. Households that cannot re-optimize their wage follow an indexation mechanism described by

$$W_{i,t+1} = (\pi_t^c)^{\kappa_w} (\varepsilon_{w,t+1}\bar{\pi})^{1-\kappa_w} W_{i,t}, \tag{3.4.19}$$

such that they index their wages to last period consumer price inflation $\pi_t^c = \frac{P_t^c}{P_{t-1}^c}$ and to the inflation target $\bar{\pi}$. The wage-indexation parameter κ_w determines the relative importance of past consumer price inflation in the indexation process. The exogenous process $\varepsilon_{w,t+1}$ is a wage-indexation shock.

Labour packer Each OH sells its labour $(h_{i,t})$ to a labour packer which transforms it into a homogeneous labour input H_t^O using the following production function:

$$H_t^O = \left[\int_0^1 (h_{i,t})^{\frac{\varepsilon_w - 1}{\varepsilon_w}} di\right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}}, \ 1 < \varepsilon_w < \infty, \tag{3.4.20}$$

where ε_w is a labour demand elasticity. This labour packer takes the input price of the i^{th} differentiated labour input as given, as well as the price of the homogeneous labour services. Consequently, the relative labour demand for labour type i is given by

$$h_{i,t} = \left(\frac{W_{i,t}}{W_t}\right)^{-\varepsilon_w} H_t^O \tag{3.4.21}$$

where $W_{i,t}$ is household j wage rate and W_t is the wage index defined by

$$W_t = \left[\int_0^1 W_{i,t}^{1-\varepsilon_w} dj\right]^{\frac{1}{1-\varepsilon_w}} \tag{3.4.22}$$

[22] This behaviour might reflect social norms or equality considerations. For example, Hall (2005) uses wage norms to rationalise its version of wage stickiness. Bewley (1999) describes the influence of social norms and equity considerations for wage decisions in the US.

Each ROTH also sells its labour $(h_{j,t})$ to a labour packer which transforms it into a homogeneous labour input H_t^R using a technology analogous to (3.4.20). Hours worked by OHs and ROTHs are perfect substitutes and every households are employed. Therefore, the aggregate labour effort available to the economy is simply given by

$$H_t = H_t^O + H_t^R = L_t \tag{3.4.23}$$

Labour dispatchers Imperfect labour mobility is introduced following Horvath (2000) and Dagher et al. (2010). Labour dispatchers hire the aggregate labour package $L_t = H_t$ at rate W_t and resell it to the primary and secondary firms at a rate W_t^p and W_t^f, respectively. They allocate labour between primary and secondary sectors using the following technology:

$$H_t = \left[(1-\omega_h)^{-1/\eta_h}(H_t^f)^{(1+\eta_h)/\eta_h} + \omega_h^{-1/\eta_h}(H_t^p)^{(1+\eta_h)/\eta_h}\right]^{\eta_h/(1+\eta_h)}, \tag{3.4.24}$$

where $H_t^p = L_t^p$ and $H_t^f = L_t^f$ denote labour effort in the primary and final sectors, respectively. The parameter ω_h is the steady-state share of primary sector employment in total employment and η_h is the elasticity of substitution between labour services provided in the two sectors. The intuition behind this specification is that there are costs associated to labour mobility such as sector specific skills. It implies that the wages effectively paid by the firms in the primary (W^p) and secondary (W^f) sectors are given by:

$$W_t^f = \left[\frac{H_t^f}{(1-\omega_h)H_t}\right]^{1/\eta_h} W_t, \tag{3.4.25}$$

$$W_t^p = \left[\frac{H_t^p}{\omega_h H_t}\right]^{1/\eta_h} W_t, \tag{3.4.26}$$

Search and matching with staggered wage bargaining

In the second model, search and matching frictions generate equilibrium unemployment. Firms post vacancies to attract unemployed workers. At every period and in each sector, a fraction of optimising workers form a union and bargain with the firms over wages per worker. The employment conditions obtained by unions apply to all their members and are extended to an identical fraction of rule of thumb workers. All other workers index their wages. The remainder of this subsection focuses on the primary sector. Equations in for the secondary sector are similar.

The matching function At every period, some unemployed workers are matched with a firm in the primary or secondary sectors. The number of matches in the primary (M_t^p) sector is given by

$$M_t^p \quad = \quad \sigma_{m,p}(\mu_t)^{\sigma_m}(V_t^p)^{1-\sigma_m} \tag{3.4.27}$$

where $\sigma_{m,p}$ is a scaling parameters and σ_m is the elasticity of matches to unemployment. The variable μ_t is the unemployment rate and V_t^p is the number of vacancies posted in the primary sectors. The number of matches in the secondary sector (M_t^f) is analogous to (3.4.27). From this matching function, it is convenient to define the vacancy filling rates:

$$q_t^p \quad = \quad \frac{M_t^p}{V_t^p} = \sigma_{m,p}\left(\frac{\mu_t}{V_t^p}\right)^{\sigma_m} \tag{3.4.28}$$

as well as the job finding rate:

$$p_t^p \quad = \quad \frac{M_t^p}{\mu_t} = \sigma_{m,p}\left(\frac{V_t^p}{\mu_t}\right)^{1-\sigma_m}. \tag{3.4.29}$$

The secondary sector vacancy filling and job finding rates q_t^f and p_t^f are similar to equations (3.4.28) and (3.4.29). At every period, any worker faces the exogenous probability δ_n to loose his job. Therefore, the laws of motion for aggregate employment in each sector and unemployment are given by

$$N_{t+1}^p \quad = \quad (1-\delta_n)N_t^p + M_t^p \tag{3.4.30}$$

$$N_{t+1}^f \quad = \quad (1-\delta_n)N_t^f + M_t^f \tag{3.4.31}$$

$$U_t \quad = \quad 2 - N_t^p - N_t^f \tag{3.4.32}$$

Vacancy posting and search costs All unemployed - and only the unemployed - households are searching for a job at no cost. Firms post vacancies to attract new workers. The cost of posting vacancies for a firm in the primary sector is given by

$$\frac{\chi}{1+\theta}\left(\frac{V_{j,t}^p}{N_{j,t}^p}\right)^{1+\theta} N_{j,t}^p P_t \tag{3.4.33}$$

where χ is a scaling parameter and $\theta > 0$ implies that the cost of posting vacancies is convex. When a match is formed, the worker receives a wage randomly drawn from the present wage distribution.[23]

[23]Since firms hire from a continuum of workers, it implies that firms consider the aggregate wage for their vacancy posting decision.

Households employment surplus Any OH i employed in the primary sector with wage $\overline{W}^{p}_{i,t}$ derives a surplus $S^{w,p}_{i,t}$ which can be expressed in monetary units:

$$
\begin{aligned}
S^{w,p}_{i,t} &= \frac{\partial \mathbb{W}_{i,t}}{\partial N_{i,t}} \left(\frac{1}{\upsilon_t}\right) \qquad (3.4.34)\\
&= \overline{W}^{p}_{i,t} - \varpi_t - \left[\frac{U(H^{p}_{i,t})}{\upsilon_t} + \beta \frac{\upsilon_{t+1}}{\upsilon_t}\left(p^{p}_{t} S^{w,p}_{t+1} + p^{f}_{t} S^{w,f}_{t+1}\right)\right] + (1-\delta_n)\beta \frac{\upsilon_{t+1}}{\upsilon_t} S^{w,p}_{i,t+1}
\end{aligned}
$$

where $U(H_{i,t})$ is the dis-utility from hours worked and υ_t is the shadow value associated with constraint (3.4.3).[24] The first two terms represent the nominal wage in excess to unemployment benefits. The terms in the brackets are the relative dis-utility of labour efforts (expressed in monetary units) and the discounted expected value from searching for a job when unemployed. The later depends on the probability to find a job in the primary or secondary sectors and on the average employees surplus in these sectors. The final term is the discounted future employee's surplus conditional on keeping the job. The employee's surplus in the final good sector $S^{w,f}_{i,t}$ is the analogue of equation (3.4.34).

Firms employment surplus Any firm j in the primary sector derives a surplus from employment which can be expressed as the discounted value of current and future profits. The present value of profits in the primary sector is given by:

$$
\mathbb{P}_{j,t} = P^{p}_{t} Y_{j,t} - \overline{W}_{j,t} N^{p}_{j,t} - \frac{\chi}{1+\theta}\left(\frac{V^{p}_{j,t}}{N^{p}_{j,t}}\right)^{1+\theta} N^{p}_{j,t} P_t - R^{k,p}_{t} K^{p}_{t} + \beta \frac{\upsilon_{t+1}}{\upsilon_t} \mathbb{P}_{j,t+1} \qquad (3.4.35)
$$

Therefore, the employer's surplus $S^{f,p}_{j,t}$ is given by

$$
\begin{aligned}
S^{f,p}_{j,t} &= \frac{\partial \mathbb{P}_{j,t}}{\partial N_{j,t}} \qquad (3.4.36)\\
&= P^{p}_{t} \frac{\partial Y_{j,t}}{\partial N^{p}_{j,t}} - \overline{W}_{j,t} + \frac{\chi\theta}{1+\theta}\left(\frac{V^{p}_{j,t}}{N^{p}_{j,t}}\right)^{1+\theta} P_t + (1-\delta_n)\beta \frac{\upsilon_{t+1}}{\upsilon_t} S^{f,p}_{j,t+1}
\end{aligned}
$$

where the first term is the value of output produced by one additional employee; the second term is the employee's wage cost; the third term captures the vacancy posting savings from having an additional worker and the final term is the expected discounted future employer's surplus conditional on keeping the worker. The employer's surplus in the final good sector $S^{f,f}_{j,t}$ is the analogue of equation (3.4.36).

[24]Therefore, $(1-\delta_n)\beta \frac{\upsilon_{t+1}}{\upsilon_t} = (1-\delta_n)\beta \frac{U'(C_{i,t+1})P^{c}_{t}}{U'(C_{i,t})P^{c}_{t+1}}$ is the stochastic discount factor.

Wage bargaining At every period, a fraction $1-\xi_w$ of workers in each firms receive a random signal.[25] Optimising workers in each sectors regroup in sector specific unions to bargain with the firm over the wage per worker $\overline{W}_t^{p*}$. Following Thomas (2008), the outcome of the bargain consists in splitting the overall employment surplus $S_t^{f,p*}+S_t^{w,p*}$ between firms and workers.[26] Wages are therefore set such that workers receive a fraction $1-\omega_w$ of the surplus. Wages negotiated between unions and firms are extended to the fraction $1-\xi_w$ of rule-of-thumb workers that received the same signal (but were not involved in the bargaining process).[27] Workers that do not receive the signal simply index their wages following equation (3.4.19).

Hours decision Following Thomas (2008), hours worked at every periods in each sectors are determined to maximise the overall present employment surplus. Hours worked are therefore independent from wages and identical for each worker in a particular sector.[28] The same conditions regarding hours works are also extended to ROTHs.

3.4.4 Public authorities

The public sector comprises a central bank and a government.

Central bank The monetary authority is assumed to follow a simple Taylor rule

$$R_t = \rho_r R_{t-1} + (1-\rho_r)\left(R + \tau_\pi \pi_t^c + \tau_{\Delta y}\left(\frac{Y_t - Y_{t-1}}{Y_{t-1}}\right) + \tau_{\Delta s}\left(\frac{S_t}{S_{t-1}}\right)\right) + \varepsilon_{R,t}, \qquad (3.4.37)$$

where ρ_r is the interest rate smoothing parameter, τ_π is the response to current consumer price inflation, $\tau_{\Delta y}$ to (real) output growth and $\tau_{\Delta s}$ to the change in the nominal exchange rate. The exogenous process $\varepsilon_{R,t}$ is a monetary policy shock. Similar Taylor rules include Lubik and Schorfheide (2007), Ortiz and Sturzenegger (2007), Liu et al. (2009), Alpanda et al. (2011) and Hove et al. (2015) for models applied to South Africa and is consistent with the adoption in February 2000 of a formal inflation targeting framework.

[25]It implies that firms remains identical regarding wage costs.

[26]Since all firms inside a sector and all re-optimising households are identical, the employers and employees surplus are identical for each firms and optimising households and the j and i indices can be dropped

[27]This assumption captures the institutional design presented in section 3. Indeed, employment conditions and wages negotiated at the Bargaining Councils level between firms and unions can be extended to non parties.

[28]All firms inside a sector are identical and therefore have the same marginal labour productivity. In the utility, hours are separable and all optimising households have the same marginal utility from consumption. Therefore, all workers supply the same amount of hours to maximise the global current employment surplus.

Government The government collects taxes on consumption, labour and capital and follows a simple public consumption rule

$$G_t = \rho_g G_{t-1} + (1-\rho_g)\bar{G} + \varepsilon_{g,t}, \tag{3.4.38}$$

where $\bar{G}$ is the steady-state value of government spendings and $\varepsilon_{g,t}$ is a government spending shock. Government consumption is composed of domestic goods only.

3.4.5 Closing market conditions and definitions

In equilibrium the goods, labour and bonds markets have to clear. The final goods market is in equilibrium when the demand from domestic households, the government and the foreign households equals the production of the final good. This aggregate resource constraint reads:

$$\left(C_t^d + I_t^d + G_t\right) \upsilon_t^d + X_t^f \upsilon_t^x \leq Y_t^f. \tag{3.4.39}$$

where

$$\upsilon_t^d = \int_0^1 \left(\frac{P_{i,t}}{P_t}\right)^{-\varepsilon_d} di \tag{3.4.40}$$

is a measure of domestic price dispersion resulting to an input loss in the domestic distribution process (3.4.13) and

$$\upsilon_t^x = \int_0^1 \left(\frac{P_{i,t}^x}{P_t^x}\right)^{-\varepsilon_x} di \tag{3.4.41}$$

is a measure of export price dispersion resulting to an input loss in the export distribution process (3.4.16). Those two price dispersion measures are bounded from below one. They imply that price dispersion increases the amount of inputs Y^f required to produce domestically consumed goods C^d, I^d or G and exported goods X^f.

The domestic bond market clears when the demand for liquidity from households equals the monetary injection by the central bank. Since the central bank money supply is perfectly inelastic at its policy rate it is not necessary to define it. The foreign bond market clears when the positions of the exporting and importing firms equal the households' choice of foreign bond holdings. Foreign assets evolve according to:

$$S_t B_{t+1}^* = R_{t-1}^* \Phi\left(A_{t-1}, \tilde{\phi}_{t-1}\right) S_t B_t^* + S_t \left(P_t^x X_t^f + P_t^{*p} Y_t^p\right) - P_t^m \left(C_t^m + I_t^m\right), \tag{3.4.42}$$

Finally, the GDP identity is defined by

$$Y_t = C_t + I_t + G_t + X_t - M_t \ , \tag{3.4.43}$$

where $I_t = I_t^p + I_t^f$; $X_t = X_t^f + X_t^p$ and $M_t = C_t^m + I_t^m$.

3.4.6 Aggregate Welfare

This subsection shows how to compute welfare for each types of households, in the two versions of the model, taking both aggregate and idiosyncratic risks into account.

Optimising households aggregate utility The aggregate utility level for OHs is given by

$$U_t^o = \int_0^1 \left[\frac{\left(C_{i,t}/(C_{t-1}^o)^b\right)^{1-\sigma_c} - 1}{1-\sigma_c} - A_h N_{i,t} \frac{(H_{i,t})^{1+\sigma_h}}{1+\sigma_h} \right] \mathrm{d}i. \tag{3.4.44}$$

Their access to complete domestic financial markets implies that all OHs have the same level of consumption at each period. In the EHL version, the fact that all households are employed and equation (3.4.21) entail that

$$U_t^o = \frac{\left(C_t^o/(C_{t-1}^o)^b\right)^{1-\sigma_c} - 1}{1-\sigma_c} - \frac{A_h (H_t^o)^{1+\sigma_h}}{1+\sigma_h} \upsilon_t^h \tag{3.4.45}$$

where C_t^o is the optimising households aggregate consumption level and

$$\upsilon_t^h = \int_0^1 \left(\frac{W_{i,t}}{W_t} \right)^{-\varepsilon_w(1+\sigma_l)} di. \tag{3.4.46}$$

The term $\upsilon_t^h \geq 1$ is a measure of hours worked dispersion (caused by wages dispersion) which results in an aggregate utility loss.

In the GTT version, the OHs aggregate utility becomes

$$U_t^o = \frac{\left(C_t^o/(C_{t-1}^o)^b\right)^{1-\sigma_c} - 1}{1-\sigma_c} - \frac{1}{2} \left(\frac{A_h N_t^p (H_t^p)^{1+\sigma_h}}{1+\sigma_h} - \frac{A_h N_t^f (H_t^f)^{1+\sigma_h}}{1+\sigma_h} \right) \tag{3.4.47}$$

where $N_t^p/2$ and $N_t^f/2$ represent the share of OHs employed in the primary and secondary sectors and hours worked can only differ between sectors.

Rule of thumb households aggregate utility ROTHs aggregate level of utility is given by

$$U_t^R = \int_0^1 \left[\frac{\left(C_{j,t}/(C_{t-1}^R)^b\right)^{1-\sigma_c} - 1}{1-\sigma_c} - A_h N_{j,t} \frac{(H_{j,t})^{1+\sigma_h}}{1+\sigma_h} \right] \mathrm{d}j. \tag{3.4.48}$$

They have no access to the financial market and have therefore no opportunity to insure against labour market idiosyncratic risks. In the EHL version, the fact that all households are employed and equations (3.4.21) and (3.4.8) imply that

$$U_t^R = \frac{\left(C_t^R/(C_{t-1}^R)^b\right)^{1-\sigma_c} \upsilon_t^c - 1}{1-\sigma_c} - \frac{A_{h,r}(H_t^R)^{1+\sigma_h}}{1+\sigma_h} \upsilon_t^h \tag{3.4.49}$$

where C_t^r is the rule of thumb households aggregate consumption level and

$$\upsilon_t^c = \int_0^1 \left(\frac{W_{j,t}}{W_t} \right)^{(1-\varepsilon_w)(1-\sigma_c)} dj. \tag{3.4.50}$$

The term υ_t^c is a measure of consumption dispersion generated by (uninsured) labour income risks and the term υ_t^h captures the hours dispersion presented in equation (3.4.46).

In the GTT version, the ROTHs aggregate utility becomes

$$\begin{aligned} U_t^R \quad &= \quad \frac{1}{2} \Bigg\{ N_t^p \frac{\left(C_t^{RP}/(C_{t-1}^R)^b\right)^{1-\sigma_c} \upsilon_t^{cp} - 1}{1-\sigma_c} + N_t^f \frac{\left(C_t^{RF}/(C_{t-1}^R)^b\right)^{1-\sigma_c} \upsilon_t^{cf} - 1}{1-\sigma_c} \\ &+ \quad U_t \frac{\left(C_t^{RU}/(C_{t-1}^R)^b\right)^{1-\sigma_c} - 1}{1-\sigma_c} - \frac{A_h N_t^p (H_t^p)^{1+\sigma_h}}{1+\sigma_h} - \frac{A_h N_t^f (H_t^f)^{1+\sigma_h}}{1+\sigma_h} \Bigg\} \end{aligned} \tag{3.4.51}$$

where C_t^{RP}, C_t^{RF} and C_t^{RU} represent the average consumption level of ROTHs employed in the primary sector, employed in the secondary sector or unemployed, respectively. These consumption levels are computed using equation (3.4.8). The terms υ_t^{cp} and υ_t^{cf} represent labour income dispersion in the primary and secondary sector, respectively. They are the analogue versions of equation (3.4.50) where $\overline{W}_{j,t}^p$ and $\overline{W}_{j,t}^f$ replace $W_{j,t}$ and $\varepsilon_w = 0$.

3.5 Empirical Methodology

This section presents the methodology. First, the different shocks introduced in the model are classified according to their types in order to reflect their potential implications for monetary policy efficiency and to ease the exposition of results. Second, it describes the value of calibrated parameters. Third, it outlines the estimation methods and the dataset. Finally, it defines the welfare cost measures.

3.5.1 Structural shocks

Table 3.1 reports the 18 innovations analysed in this paper. In order to summarize their implication for monetary policy and to ease the exposition of key results, these shocks are classified: first according to their origin and then according to their type.

Table 3.1: Structural shocks

	Symbol	Process	Group	Description
Foreign shocks				
Wedge	$\varepsilon^*_{b,t}$	AR(1)	AD*	Wedge btw policy and private interest rates
Government demand	$\varepsilon^*_{g,t}$	AR(1)	AD*	Government consumption shock
Monetary policy	$\varepsilon^*_{R,t}$	IID	AD*	Deviation from Taylor Rule
Productivity	$\varepsilon^*_{k,t}$	AR(1)	(R)AS*	Capital specific productivity shock
Investment specific	Υ^*_t	AR(1)	(R)AS*	Investment efficiency shock
Commodity supply	$\varepsilon^*_{p,t}$	MA(1)	(R)AS*	Foreign commodity supply shock
Price indexation	$\varepsilon^*_{\pi,t}$	IID	(N)AS*	Price-push shock in indexation process
Wage indexation	$\varepsilon^*_{w,t}$	IID	(N)AS*	Wage-push shock in indexation process
SOE shock				
Country risk premium	$\tilde{\phi}_t$	AR(1)	SOE	Affecting the UIP condition
Trade shock	$\varepsilon_{\omega,t}$	ARMA(1)	SOE	Home bias in the domestic and foreign eco.
Domestic shocks				
Wedge	$\varepsilon_{b,t}$	AR(1)	AD	Wedge btw policy and private interest rates
Government demand	$\varepsilon_{g,t}$	AR(1)	AD	Government consumption shock
Monetary policy	$\varepsilon_{R,t}$	IID	AD	Deviation from Taylor Rule
Productivity	$\varepsilon_{k,t}$	AR(1)	(R)AS	Capital specific productivity shock
Investment specific	Υ_t	AR(1)	(R)AS	Investment efficiency shock
Commodity supply	$\varepsilon_{p,t}$	AR(1)	(R)AS	Domestic commodity supply shock
Price indexation	$\varepsilon_{\pi,t}$	IID	(N)AS	Price-push shock in indexation process
Wage indexation	$\varepsilon_{w,t}$	IID	(N)AS	Wage-push shock in indexation process

There are three broad categories of shocks defined according to their origin: domestic, foreign, and SOE shocks. Domestic and foreign shocks are disturbances that are unambiguously identified from domestic and foreign origins, respectively. SOE shocks, on the other hand, are disturbances that may have both domestic and foreign origins. In particular, the country risk premium shock could be explained by a change in domestic country risk (beyond what is captured by the net foreign asset position) or by a change in foreign risk aversion leading to a revision of the price of exchange rate risks. It is therefore labelled as a SOE shock.

Domestic and foreign shocks are classified in 2 sub-groups. On the one hand, aggregate demand shocks (AD) include wedge[29], government consumption and monetary policy shocks. On the other hand, aggregate supply shocks (AS) consist of three real (R) technology shocks:

[29] The wedge shock is usually considered as a financial shocks. Considering that its main impact is on consumption and investment demands, it qualifies as a demand shock.

capital productivity, commodity supply and investment specific shocks as well as two nominal (N) disturbances: price indexation and wage indexation shocks.

3.5.2 Calibration

Table 3.10 in the appendix shows the value of calibrated parameters. Most of them are set in order to fit the empirical mean observed in the data. The relative importance of labour in utility A_h is calibrated such that agents devote 30% of their time to labour activities (which only represents a choice of units). The annual inflation rate is set to 6%. It corresponds to the upper band of the South African Reserve Bank inflation target and is close to its empirical mean. The discount factor β is set to 0.99 in order to match the average real risk-free rate. The depreciation rate is set to 0.02 in order to match the investment to GDP ratio. The capital income share is set to 1/3 in both sectors. The land share β_p is calibrated to 0.31 to ensure that the mining sector represents 10% of GDP while households devote 6% of their labour efforts to this sector on average. The share of imports in consumption ω_c and investment ω_i are set to 0.3 and 0.5, respectively. Those values imply an import to GDP ratio of about 28% as observed in the data. The net foreign asset position is set to 0 at steady-state for simplicity. The government consumption to GDP ratio is set to 19.5%.

Two parameters present in the EHL and GTT versions of the model deserve particular attention. First, the foreign interest rate elasticity to net foreign asset position ϕ_a captures the degree of integration of the emerging economy in global financial markets. As ϕ_a decreases, the costs of international risk sharing decreases and so does the welfare costs of business cycles. Adolfson et al. (2007) calibrate this parameter to 0.01. However, Brzoza-Brzezina and Kotlowski (2016) argue that this value depends on the initial debt level and could be as low as 0.0001. In the baseline model, ϕ_a is calibrated to 0.001. Second, the input demand elasticity ε_d influences the output wastes presented in equations (3.4.40) and (3.4.41) generated by inflation volatility. This parameter is set to 11 in the baseline. It implies that distributors impose a 10% mark-up on their marginal costs. The net profit margin that fluctuated between 6 and 12% for the 2001-2015 period (Annual financial statistics 2015, Stat SA).

Some parameters are specific to the labour market and are crucial since they generate idiosyncratic risks. In the EHL framework, labour demand elasticity ε_w influences hours and consumption dispersion in equations (3.4.46) and (3.4.50) with important welfare implications. This parameter is set to 11 and the implied labour income dispersion is confronted to the data. Considering that many factors beyond the mechanisms described in this paper could generate income inequality, it is important to check that this model does not generate more income dispersions than what is actually observed. The EHL version of the model generates an average within individual coefficient of variation of 0.15.[30] The South African National Income Dy-

[30]The within individual coefficient of variation takes, for each individual, the ratio of its standard deviation in

namics Study (NIDS) database provides information on income at the household level. Ranchhod (2013) describes this database and computes the average within-individual coefficient of variation to argue that income is very volatile at the household level in South Africa. He reports a value of 0.64 using the first three waves of the NIDS. Restricting the analysis to households employed in the four waves of this study (there is no unemployment in the EHL version of the model), removing the growth trend in income (due to both inflation and real income growth) and excluding the first income percentile give an mean within individual coefficient of variation of 0.27, still above the value implied by the model. In the GTT framework, the equilibrium unemployment rate is calibrated to 10%. Although the unemployment rate in South Africa remained close to 25% over the estimation period, more than 60% of the unemployed are classified as long term unemployment (OECD data and Banerjee et al. (2008)). Calibrating the unemployment rate to 10% therefore offers a better description of the transitory unemployment dynamics generated by the model. The (quarterly) separation rate δ_n is calibrated to 0.07 based on the labour market transition probabilities in Anand et al. (2016). This assumptions generates a job finding rate of 4% and 59% in the primary and secondary sectors (based on the Beveridge Curve). The scaling parameters $\sigma_{m,p}$ and $\sigma_{m,f}$ in the matching function are adjusted such that the probability to fill a vacancy equals 0.5 at steady-state and χ is set such that hiring cost represents 1% of GDP following Thomas (2008). The unemployment benefits ϖ represent 42% of the steady-state wage and imply that the worker share of the employment surplus ω_w equals 60%. The GTT framework generates a within-individual coefficient of variation of 0.34 for labour incomes (assigning a zero wage to the unemployed).

3.5.3 Bayesian estimation

This subsection presents the dataset, the value of some key estimated parameters and their identification.

Data

The model is estimated with Bayesian methods using 11 domestic and 8 foreign variables. The data set includes domestic GDP; private consumption; investment; government consumption and commodity exports; employment; consumer price index; import price index; aggregate wage index; risk free rate; and nominal effective exchange rate. Commodity exports are proxied by sales in the mining sector (about 70% is exported). Foreign variables include GDP; private consumption; investment; government consumption, consumer price index; wages; risk free rate; hours worked and commodity price. US data are used to proxy the foreign economy.[31] Commodity prices are measured as an average of world coal, platinum, silver, gold

income (over time) to its average income.

[31] G7 data were use as a robustness check in Houssa et al (forthcoming).

and aluminium prices. It includes important South African commodities. Since there are more observed variables than shocks, estimated measurement errors are introduced on the domestic price and wage indexes as well as on the domestic and foreign GDPs. Data range from 1994Q1 to 2016Q1 in order to exclude the apartheid period in South Africa (characterised by political and economic instability).[32]

Estimated parameters

Shocks processes, rigidities and policy rule interact to generate business cycles and further interplay with the utility function to translate into welfare costs. This subsection describes the value of estimated parameters and discusses their identification. In particular, it focuses on the persistence and magnitude of estimated business cycles shocks, on the importance of nominal and real frictions and on the estimated monetary policy rule followed by the central bank. The priors and posteriors of some key estimated parameters with specific welfare implications are reported in Figure 3.3 and 3.4 in the appendix. The full set of estimated parameters is described in Tables 3.11 and 3.12 also in the appendix.

Identification The methodologies proposed by Andrle (2010) and Iskrev (2010) implemented in Dynare revealed some cases of weak identification. First, Iskrev (2010) collinearity analysis shows that elasticities of substitution η_c in the consumption basket (3.4.2) and η_i in the investment basket (3.4.7) suffer from perfect collinearity. Considering the fact that these two parameters are conceptually similar, they were constrained to take the same value in the estimation. Second, the labour supply elasticity σ_l in (3.4.1) is weakly identified. It is due to its minor marginal effect on the likelihood function and to collinearity patterns with some parameters such as the elasticity of substitution between labour services η_h in (3.4.24) in the EHL version of the model. Looking at the prior and posterior distributions of σ_l it is clear that the impact of the prior is substantial for both versions of the model. Therefore, the prior (which is relatively wide) plays an important role. An alternative would be to calibrate this parameter and perform some robustness exercises. However, since this parameter is identical for each categories of households in the domestic and in the foreign economy, it should not cause difference among each groups. Third, Andrle (2010) singular value decomposition of the Fischer information matrix shows that the investment adjustment costs (both in the domestic and foreign block) are the weakest identified parameters in the final estimation. Although their marginal impact on the likelihood is high, these parameters suffer from collinearity with the investment shocks variance and persistence. The investment shock persistence is therefore calibrated to 0.5. It nevertheless means that a perfect identification of the welfare effects of this specific

[32] Houssa et al (forthcoming) also experiment stopping in 2010Q1 in order to avoid most of the zero lower bound period in the US (which is difficult to capture with a simple Taylor rule) as well as starting in 2000Q1 which corresponds to the introduction of formal inflation targeting in South Africa.

friction would be difficult. Nominal rigidities are on the other hand properly identified.

Shocks magnitude and persistence Large and persistent shocks are known to generate larger welfare effects. Table 3.11 shows the standard deviation and persistence of each shock and indicates that domestic disturbances tend to be larger but less persistent, on average. This is particularly true for the capital specific and commodity sector TFP shocks. Demand shocks do not display such a difference, although the wedge shock seems slightly more volatile and more persistent in the emerging economy. Nominal cost-push shocks are similar in the domestic and foreign economies while wage-push shocks are slightly larger in the former.

Nominal rigidities Nominal price and wage rigidities are crucial since they reduce firms and households ability to adjust their prices and wages to business cycle fluctuations. They generate price and wage dispersions that are costly in term of welfare. Based on the EHL version of the model (which is the only assumption used to model the foreign economy block) domestic prices and wages seem to be less rigid in South Africa, when compared to the US. It is therefore unlikely that this amount of nominal rigidities could amplifies the cost of business cycle fluctuations when compared to advanced countries. However, incomplete exchange rate pass-through is important and implies potentially inefficient deviations from the low of one price. Compared to the EHL version of the model, the GTT staggered wage parameter is larger. The average contract lasts almost two years.

Real rigidities Real rigidities are also important since they can impair the reallocation of resources across time or sectors. Investment adjustment costs ($\tilde{S}''$) are larger in the domestic economy. In addition, labour mobility accross sectors is small (η_h<1) in the EHL version of the model.[33] These relatively important real rigidities might exacerbate the costs of business cycle fluctuations by preventing (individually) optimal resources reallocations, but might also dampen the transmission of some exogenous disturbances and reduce the volatility in some aggregate variables (for given shocks processes).

Utility parameters In order to focus on the welfare effects of business cycles, independently from potential differences in preferences, the utility parameters (σ_c, b and σ_h) are identical for each categories of households. Moreover, since ROTHs do not maximise their utility, it is not possible to infer their preferences from their decisions. The inverse of the labour supply elasticity (σ_h) is not well identified and its posterior distribution is close to its prior. Its distribution reflects relatively large uncertainty around the value of this parameter. The coefficient

[33] η_h is calibrated to one in Horvath (2000) and Dagher et al. (2010). There is no equivalent in the GTT variant or in the foreign economy since commodity supply is assumed to be exogenous for simplicity.

of relative risk aversion (σ_c) and external habits (b) are both relatively high and would therefore support high welfare costs of business cycles fluctuations for each types of agents in the domestic and foreign economies.

Taylor Rule The coefficients of the estimated Taylor rule show that the SARB responded to inflation fluctuations (τ_π=1.69 and 1.62 in the EHL and GTT versions of the mode, respectively), which is consistent with its mandate and the introduction of inflation targeting. In addition, changes in interest rate were smooth (ρ_r=0.86 and 0.87) and the SARB responded to output growth ($\tau_{\Delta y}$=0.53) and to the change in the nominal exchange rate ($\tau_{\Delta s}$=0.12 and 0.13). These results are close to the prior. However, they are also relatively close to the literature (on which the prior are based) and will serve as a benchmark for comparing the costs of business cycles under different monetary policy rules. Note that the Taylor rule in the foreign economy is calibrated in order to avoid an estimation on the zero lower bound period.

3.5.4 Welfare measures

Welfare cost of business cycle This paper measures the welfare cost of business cycle fluctuations in the emerging economy using a second order approximation to the model (Schmitt-Grohe and Uribe (2004)).[34] The welfare cost of business cycles is defined along the lines of Lucas (1987) as the share of consumption that an agent would be ready to give-up at every period to insulate the economy from all shocks and therefore eliminate aggregate fluctuations. This measure is provided for the two categories of domestic households and compared to the foreign economy serving as a benchmark. A second order approximation implies that the variance of shocks can have an impact on the mean of endogenous variables. This could make the volatile environment artificially attractive if, for example, precautionary motives would encourage capital accumulation. Conditional welfare measures are therefore computed. They solve this issue by imposing that all simulations (i.e. with or without shocks) start from the same initial point (including the same value of capital). In this paper, this common starting point is the deterministic steady-state. Unconditional welfare cost measures are also reported. They should be interpreted as the long-term cost of business cycles after agents are done accumulating precautionary assets.

Comparison of simple policy rules This paper also explores potential welfare gains from alternative monetary policy rules. It focuses on simple and implementable monetary rules (Schmitt-Grohe and Uribe (2007)). Those rules determine the response of policy variables as a function of a small number of easily observable macroeconomic indicators (such as inflation,

[34]The literature has also used the linear-qudratic approach of Benigno and Woodford (2005) and Benigno and Woodford (2012). Although this approach delivers a closed form (as a function of deep parameters) solution to the welfare loss function, the complexity of this model would make computation difficult.

output and exchange rate measures) and deliver uniqueness of the rational expectation equilibrium. As such, they include the rule advocated by Taylor (1993) as well as most modified versions proposed in the literature. A simple evaluation of conditional aggregate welfare measures would be enough in order to rank alternative policy rules. However, conditional compensation measures are also provided in order to assess the magnitude of the difference in welfare. It is defined as the fraction of consumption that an agent would be ready to abandon in order to be transferred from the benchmark economy to an alternative economy. The computations are provided in appendix D.

3.6 Empirical Results

This section presents the results. First, it computes the welfare cost of business cycle fluctuations. Second, describes the impact of alternative simple monetary policy rules on welfare and searches for an optimal simple rule.

3.6.1 Welfare costs of business cycles

This section has two sets of objectives. First, it shows that the costs of business cycles are relatively large in the emerging economy - especially for ROTHs - and it highlights the role of financial markets exclusion. Second, it evaluates the welfare effects of each type of shocks. It shows that each category of shocks is associated with substantial business cycle costs. Surprisingly, commodity price volatility could be welfare increasing for plausible sets of parameters.

Welfare costs of business cycles and the role of financial markets

This section evaluates the welfare costs of business cycle fluctuations for each type of agents in the EHL and GTT versions of the model. Moreover, it assesses the importance of insurance market exclusion for ROTHs by computing welfare costs in two environment. First, this paper reports a baseline measure that reflects complete asset markets exclusion as described in the model section. Second, it evaluates these costs assuming that these households are excluded from capital and bonds markets but are able to trade in state-contingent assets. In this case, ROTHs are capable to insure against labour market idiosyncratic risks and remain homogeneous regarding their consumption levels. In the EHL framework, there is only one type of labour market idiosyncratic risks which is the staggered wage setting mechanism generating labour income dispersion. ROTHs utility in equation (3.4.49) is recomputed assuming that $\upsilon_t^c = 1$ to shut-down this risk. In the GTT version of the model, there are three distinct layer of labour market idiosyncratic risks: households face staggered wage negotiations, sector specific average wage differentials and unemployment risks. The utility in equation (3.4.52) is therefore re-evaluated with $C_t^{RP} = C_t^{RF} = C_t^{RU}$ and $\upsilon_t^{cp} = \upsilon_t^{cf} = 1$ to remove all of these risks. Moreover, the welfare costs of business cycles are computed for some intermediate levels of risk sharing. It is assumed that households share risks with their peers in their sectors ($\upsilon_t^{cp} = \upsilon_t^{cf} = 1$ and $C_t^{RP} \neq C_t^{RF} \neq C_t^{RU}$) or with all workers ($\upsilon_t^{cp} = \upsilon_t^{cf} = 1$ and $C_t^{RP} = C_t^{RF} \neq C_t^{RU}$) in order to assess the relative importance of each type of risk.

Table 3.2: Welfare costs of business cycles

EHL model	Cdt cost	Relative to OHs	Relative to ROTHs	Uncdt cost
OHs	0.547	1	0.217	-0.911
	(0.268 ; 0.941)	(1 ; 1)	(0.124 ; 0.309)	(-1.686 ; -0.334)
ROTHs	2.443	4.612	1	1.707
	(1.994 ; 3.651)	(3.235 ; 8.095)	(1 ; 1)	(1.077 ; 2.945)
RoTHs: perfect RS	0.494	0.914	0.195	-0.433
	(0.287 ; 0.771)	(0.76 ; 1.113)	(0.125 ; 0.276)	(-0.979 ; -0.033)
OHs*	0.371	0.7	0.147	0.445
	(0.272 ; 0.545)	(0.4 ; 1.206)	(0.099 ; 0.216)	(0.326 ; 0.642)
GTT model	Cdt cost	Relative to OHs	Relative to ROTHs	Uncdt cost
OHs	0.743	1	0.568	-0.463
	(0.473 ; 1.152)	(1 ; 1)	(0.454 ; 0.687)	(-1.086 ; 0.008)
ROTHs	1.305	1.754	1	0.496
	(0.862 ; 1.921)	(1.457 ; 2.205)	(1 ; 1)	(-0.095 ; 1.197)
RoTHs: sectoral RS	1.215	1.627	0.927	0.385
	(0.805 ; 1.788)	(1.333 ; 2.041)	(0.907 ; 0.948)	(-0.187 ; 1.022)
ROTHs: workers RS	1.212	1.617	0.923	0.377
	(0.801 ; 1.781)	(1.327 ; 2.033)	(0.899 ; 0.945)	(-0.193 ; 1.012)
RoTHs: perfect RS	0.545	0.724	0.411	-0.297
	(0.378 ; 0.785)	(0.629 ; 0.823)	(0.34 ; 0.482)	(-0.65 ; 0.015)

Note: Welfare costs expressed a percentage point of (permanent) steady-state level of consumption. Conditional costs in the first column assume that the stochastic economy initially starts from its deterministic steady-state. Second and third columns report relative costs expressed as ratios of conditional costs for each agents compared to two different benchmarks: OHs and ROTHs respectively. Unconditional costs in the last column. Mode and 90% confidence bands reported in parenthesis.

The upper panel in Table 3.2 presents the welfare costs of business cycle fluctuations in the EHL version of the model for OHs, ROTHs, insured ROTHs and foreign agents; respectively. It shows that OHs would be ready to give-up 0.55% of their steady-state level of consumption in order to avoid macroeconomic fluctuations while ROTHs would be ready to offer 2.44%. Those costs are larger than in the advanced economy: foreign households would renounce to 0.37%. Having access to state-contingent assets, these costs would drop from 2.44% to 0.49% for ROTHs. The lower panel in Table 3.2 reports the welfare costs of business cycle fluctuations in the GTT framework. In this case, the welfare costs of business cycles represent 0.74% and 1.31% of steady-state consumption for OHs and ROTHs, respectively. In addition to the baseline - where ROTHs are excluded from all assets markers - three alternative assumptions regarding risk sharing are made. First, when ROTHs are able to share risks with their peers working in the same sector, the welfare cost of business cycles declines to 1.22%. Therefore, the inability to insure against staggered wage bargaining risks generating wage dispersion in each sector exacerbates the welfare costs of business cycles for about on tenth of a percentage point of steady-state consumption. This is much below the equivalent staggered wage setting risk in the EHL framework but economically meaningful. Second, when they are additionally able to share risk with all employed households, thereby cancelling sector specific wage differentials, the welfare cost of business cycles barely changes. Sectoral differences in average wages therefore seems to play a marginal role. In the GTT framework, wages in one sector influence wage bargaining in the other sector via its impact on employees outside option. Average wages in the primary and secondary sectors are therefore highly correlated. Moreover, only a small fraction of the workers are employed in the primary sector. This makes the effects of risk sharing between sector marginal. Third, when they are allowed to share risks all together, the welfare cost of business cycles drops to 0.55%. It indicates that unemployment risks are crucial.

In both versions of the model, the welfare costs of business cycles are particularly high, in relative term, for domestic financially excluded households. Indeed, they would be ready to abandon between 3.2 and 8.1 times as much, as a fraction of steady-state consumption, than OHs in order to avoid macroeconomic fluctuations in the EHL framework; and between 1.5 and 2.2 times as much in the GTT version of the model. Assuming that ROTHs could insure against idiosyncratic risks, their welfare costs of business cycles would likely be below those of their financially included counterparts. This result shows that exclusion from insurance markets is the key factor explaining the gap in the welfare costs of business cycles between financially included and excluded households.

Two mechanisms explain why financial markets exclusion exacerbates the welfare costs of business cycles in both versions of the model. First, lets consider wage rigidities. In the EHL context, a typical business cycle downturn encourages households to adjust their wage. Wages rigidities imply that a faction of agents cuts on their hourly wage rate while others simply index their wages to past inflation. Any household therefore faces the risk to end up with a relatively large wage - compared to other workers - and to suffer drastic drop in hours worked and income (the hours effect dominates because the labour demand elasticity of substitution is usually very large). Under the GTT assumption, a similar downturn decreases the firms employment surplus and the employees outside options. For the unlucky households facing wage renegotiation, wages are cut. In both versions of the model, financially included households can trade in state-contingent asset markets to mute these risks. However, unlucky excluded households have no other choice than to adjust their consumption expenditures to their income with large detrimental welfare effects. Since households are risk averse, these unequal consumption levels has a detrimental effect on aggregate welfare. The magnitude of the implied consumption dispersion is however very different in both versions of the model. Under the EHL hypothesis, the high individual labour demand elasticity to wages generates larger labour income dispersion and therefore has very large welfare effects. Second, and specifically to the GTT variant, unemployment idiosyncratic risks exacerbate the welfare costs of business cycles for ROTHs. As already mention, unemployment benefits are tied to previous labour incomes.[35] Consequently, it is worse to be laid-off during a recession because replacement wages are low.[36] Business cycle fluctuations therefore generate income fluctuations when households are the most vulnerable. Since their consumption levels are very low when unemployed, they are ready to pay a large premium at every time and date to avoid further consumption volatility when unemployed. The welfare gains from eliminating aggregate fluctuations are important because households already face substantial amounts of uninsurable unemployment idiosyncratic risks.[37]

Surprisingly, bonds and capital markets exclusion do not amplify the welfare costs of business cycle fluctuations. Actually, exclusion from bonds and capital markets does not increase consumption volatility and consequently does not raise the welfare costs of business cycles fluctuations. Two characteristics of the model provide the explanation. First, consumption is usually more volatile than output in emerging markets. However, ROTHs consumption follows income and therefore cannot be much more volatile than GDP. It implies that OHs consumption volatility need to adust to match the aggregate consumption volatility.[38] Second, there are important risks associated to holding any types of assets and to saving or borrowing in foreign bonds in particular. Following Schmitt-Grohe and Uribe (2003), the interest rate on foreign bonds depends on the net foreign assets position of the domestic economy (which captures the country risk premium and ensure stability of the model). By definition, the net foreign assets position depends on the cumulated trade balance surplus and deficits. Since a large share of exports are commodities whose prices are extremely volatile and persistent, it is subject to relatively large swings. This affects the country risk premium and OHs consumption/savings decisions. Moreover, holding primary sector capital is also very risky. These two specificities of the model explain why capital and bonds markets exclusion does not amplify *the welfare costs of business cycles* for households *having access to the insurance markets*. Some words of caution relate to the interpretation of this last result. This paper does not provide evidence

[35] In practice, unemployment benefits are linked to past individual wages in South Africa. However, for simplicity, it is assumed that they are based on aggregate wages.

[36] Other arguments have been developed in the literature to show that it is worse to be laid-off during recessions. Krebs (2007) considers that long term earning losses of displaced workers are larger during recessions due to lower entry wages or foregone wage rise. Krusell et al. (2009) recognize that prolonged periods of unemployment - which are more likely during recessions - exhaust poor households savings with large welfare effects. Specifically to the South African context, prolonged periods of unemployment end unemployment benefits.

[37] Santis (2007) show that idiosyncratic consumption risks can increase the gain of macroeconomic stability because the marginal gain from more stability is higher when the total amount of risk is large.

[38] Bhattacharya and Patnaik (2016) find a similar result.

on the effects of bonds and capital markets exclusion when households have no access to insurance. It would requires a third category of households - having access to bonds and capital but excluded from state contingent asset markets - that cannot be accommodated in a typical DSGE model.[39] In this framework, one would expect bonds to play a crucial role as a self insurance tool. Moreover, this latter result does not mean that bonds and capital markets exclusion does not generate inequality. In this model, it actually does: bonds and capital increase the average level of consumption although they do not decrease its volatility.

Sources of the business cycle fluctuations and welfare costs

This section explores the relative importance of different types of shocks classified by nature (AD, NAS, RAS) and origin (domestic, foreign, SOE) in driving business cycles and generating welfare costs in the emerging economy. The sources of business cycle fluctuations and welfare costs have important implications for monetary policies. On the one hand, domestic monetary policies are especially well armed to deal with demand shocks. Therefore, an economy mainly driven by domestic demand factors would benefit the most from domestic demand management policies. On the other hand, supply disturbances entail a trade-off in term of inflation and output volatility. In addition, real supply shocks affect the natural level of output implying that, even if feasible, perfect output stabilisation would not be optimal. Similarly, foreign sources of disturbances can force a trade-off in term of inflation, output and exchange rate stabilisation to the domestic monetary policy.

The variance decomposition analysis reported in Table 3.13 in the appendix describes the sources of business cycle fluctuations at a five years horizon. Domestic real aggregate supply (RAS) shocks are the most important drivers of GDP fluctuations and also explain a large share of the fluctuations in hours worked. Domestic nominal aggregate supply (NAS) shocks are responsible for most of the fluctuations in domestic prices and wages. Together, domestic aggregate supply shocks contribute to a large fraction of the fluctuations in output and prices. However, these shocks do not trigger important monetary policy responses, probably because of the inflation/output trade-off they impose. Domestic aggregate demand (AD) shocks are the second driver of GDP and are the primary focus of monetary policy. Excluding monetary policy shocks, they explain almost 50% of the variance in nominal interest rates. Foreign shocks also contribute to the fluctuations in domestic variables. Among foreign shocks, commodity supply shocks are the most important. These shocks generate important consumption fluctuations, especially for ROTHs. SOE shocks also weight on domestic variables via their effects on trade and the exchange rate.

The welfare cost analysis in Table 3.3 evaluates the fraction of consumption that each type

[39]Idiosyncratic risks would make this type of agent heterogeneous with respect to capital and bonds holding and the representative agent framework would break. A way around would be to assume that this type of agents also applies simple rules of thumbs for their savings decisions.

Table 3.3: Welfare costs decomposition by disturbances

	EHL model		**GTT model**	
NO AD	Cdt cost	Premium	Cdt cost	Premium
OHs	0.341	0.168	0.408	0.316
	(0.152 ; 0.569)	(0.077 ; 0.506)	(0.234 ; 0.651)	(0.174 ; 0.647)
ROTHs	1.725	0.689	0.842	0.458
	(1.495 ; 2.164)	(0.338 ; 1.852)	(0.52 ; 1.287)	(0.254 ; 0.877)
NO RAS	Cdt cost	Premium	Cdt cost	Premium
OHs	0.513	0.032	0.606	0.136
	(0.244 ; 0.902)	(0.022 ; 0.045)	(0.351 ; 0.983)	(0.102 ; 0.181)
ROTHs	2.346	0.092	1.281	0.025
	(1.907 ; 3.569)	(0.075 ; 0.113)	(0.849 ; 1.906)	(0.002 ; 0.051)
NO NAS	Cdt cost	Premium	Cdt cost	Premium
OHs	0.381	0.168	0.62	0.134
	(0.134 ; 0.749)	(0.135 ; 0.22)	(0.359 ; 0.988)	(0.106 ; 0.168)
ROTHs	1.624	0.828	1.222	0.087
	(1.154 ; 2.835)	(0.694 ; 1.051)	(0.797 ; 1.813)	(0.044 ; 0.151)
NO SOE	Cdt cost	Premium	Cdt cost	Premium
OHs	0.644	-0.099	0.851	-0.092
	(0.407 ; 1.009)	(-0.174 ; -0.058)	(0.579 ; 1.238)	(-0.147 ; -0.053)
ROTHs	2.364	0.074	1.327	-0.021
	(1.908 ; 3.555)	(0.034 ; 0.132)	(0.902 ; 1.978)	(-0.071 ; 0.023)
NO AD*AS*	Cdt cost	Premium	Cdt cost	Premium
OHs	0.269	0.241	0.497	0.234
	(0.139 ; 0.634)	(0.117 ; 0.451)	(0.319 ; 0.83)	(0.093 ; 0.436)
ROTHs	1.757	0.687	0.539	0.741
	(1.314 ; 2.893)	(0.467 ; 1.027)	(0.31 ; 1.062)	(0.431 ; 1.174)

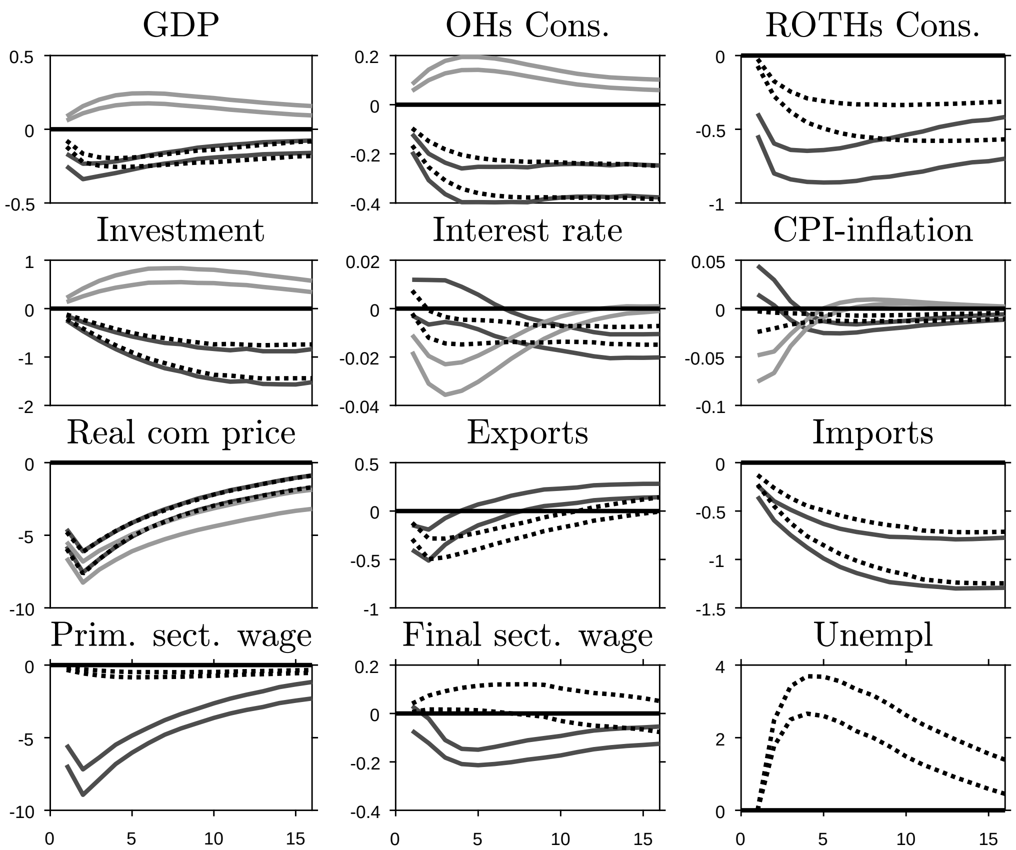
Note: The first column in each panels represents the welfare costs of business cycles in an economy sheltered from one particular group of shocks. See Table 3.1 for the definition of these groups of shocks. The second column shows the premium (as a fraction of consumption) that an agent would be ready to give to be transferred from the baseline to this particular economy. All numbers expressed in percentage points. Mode and 90% confidence bands reported in parenthesis.

of households would be ready to give-up in order to insulate the economy from one particular group of shocks (starting from the baseline economy whose business cycles are driven by all shocks). OHs are mainly affected by domestic aggregate demand, nominal aggregate supply and foreign shocks. Their effects are similar in term of magnitude in both versions of the model. For ROTHs, domestic aggregate demand and foreign shocks are important in both versions of the model. However, nominal aggregate supply shocks represent the largest source of welfare costs in the EHL version of the model while they only play a small role in the GTT framework. In the EHL framework, wage inflation generates more wage dispersion which translates into costly consumption dispersion. Since nominal supply shocks are responsible for the largest share of wage volatility, they are very important under the EHL hypothesis.

Commodity price fluctuations and option effects

Among foreign sources of business cycle fluctuations, commodity supply shocks would be a natural suspect to explain the large welfare costs of business cycles in the emerging economy. Foreign commodity supply shocks, through their impact on commodity prices, have large repercussions on the domestic economy and generate important consumption, investment and exchange rate fluctuations.

Figure 3.1: Foreign commodity supply shock: IRFs



Note: Domestic variables in the EHL version in solid black line, in the GTT version in dashed black and foreign variables in grey. 90% confidence bands. Variables are expressed in percentage deviation from steady-state. Wage in real per employee income. Horizon in quarters.

Figure 3.1 depicts the response of domestic and foreign variables to foreign commodity supply shock (in the EHL and GTT versions of the model). In the foreign economy, an exogenous increase in global commodity production generates a boom: it lowers commodity prices and acts as a positive supply shock by reducing firms marginal costs. In the domestic economy, this contraction in mining prices triggers a drop in mining production. Revenues from mining activities collapse damaging the trade balance (in nominal term) and leading to a build up of foreign debt. This increases the risk associated to the domestic currency. In addition, anticipations of lower output and inflation rates (from lower aggregate demand) resulting in lower domestic interest rates further play against the domestic currency. The exchange rate surges. Lower exports revenues and higher import prices depress imports, consumption and investments. In the EHL framework, the initial drop in consumption is larger for ROTHs who face lower labour earnings and cannot access financial markets to smooth consumption. In the GTT framework, search and matching frictions generate a delay between the shock and the peak in unemployment which causes an hump-shaped response in ROTHs consumption.

What are the effects of foreign commodity supply shocks on domestic households welfare? Surprisingly, they are welfare increasing for financially included households. Moreover, they could also raise excluded households welfare depending on the version of the model (see Table 3.4). Actually, although the entailed volatility in aggregate variables such as consumption is unambiguously welfare decreasing, foreign commodity supply fluctuations could also have positive effects for at least two reasons. First, commodity supply volatility increases the average price of commodities relative to the final good in the foreign economy. The final good production function in the foreign economy (equation 3.4.11) implies that the price of commodities depends on their availability relative to other production factors (expressed as the capital and labour value added to commodity supply ratio).[40] As commodity supply volatility increases, the average value of this ratio also increases and so does the average commodity price. This translates into better term of trade, on average, for commodity exporters such as the emerging economy considered in this paper. Households can therefore sustain a higher average level of consumption for a given average level of commodity exports. Second, commodity price fluctuations offer option effects, which are the focus of the remainder of this subsection.

How do option effects works for commodity prices? As an introduction, lets consider a simple example. Assume that a firm produce one unit of commodity at period one and period two. Imagine that there are no business cycle fluctuations and that commodity prices are fixed to one. The producer's income amounts to one monetary unit at every period, hence two in total. Now imagine prices are subject to mean-preserving fluctuations. At period one, the price is equal to 1.5; at period two to 0.5. If the producer does not adjust, his income remains equal to two (1.5 plus 0.5). But imagine that the employer can convince his employees to work twice as hard on period one (to produce two units), and to have a break at period two (hence no production). By transferring production from period two to one, he could get an income of three (1.5 times 2). Could this strategy increase welfare? It could, depending on the ability to transfer resources from period one to period two and on employees preferences for smooth working hours and income streams. In the more realistic economy presented in section four, the same intuition is valid. Indeed, option effects could compensate or even dominate the adverse

[40] See equation (3.8.23) in the appendix.

Table 3.4: Welfare cost of foreign commodity supply and commodity price shocks

	EHL model		GTT model	
Com supply shock*	Cdt cost	Uncdt cost	Cdt cost	Uncdt cost
OHs	-0.097	-0.215	-0.141	-0.222
	(-0.139 ; -0.061)	(-0.349 ; -0.146)	(-0.222 ; -0.093)	(-0.357 ; -0.142)
ROTHs	0.122	0.064	-0.211	-0.215
	(0.03 ; 0.253)	(-0.019 ; 0.174)	(-0.302 ; -0.147)	(-0.314 ; -0.137)
Com price shock*	Cdt cost	Uncdt cost	Cdt cost	Uncdt cost
OHs	0.002	-0.167	-0.035	-0.141
	(-0.024 ; 0.029)	(-0.239 ; -0.109)	(-0.059 ; -0.013)	(-0.194 ; -0.099)
ROTHs	0.339	0.263	0.058	0.022
	(0.275 ; 0.448)	(0.192 ; 0.376)	(-0.004 ; 0.134)	(-0.065 ; 0.126)

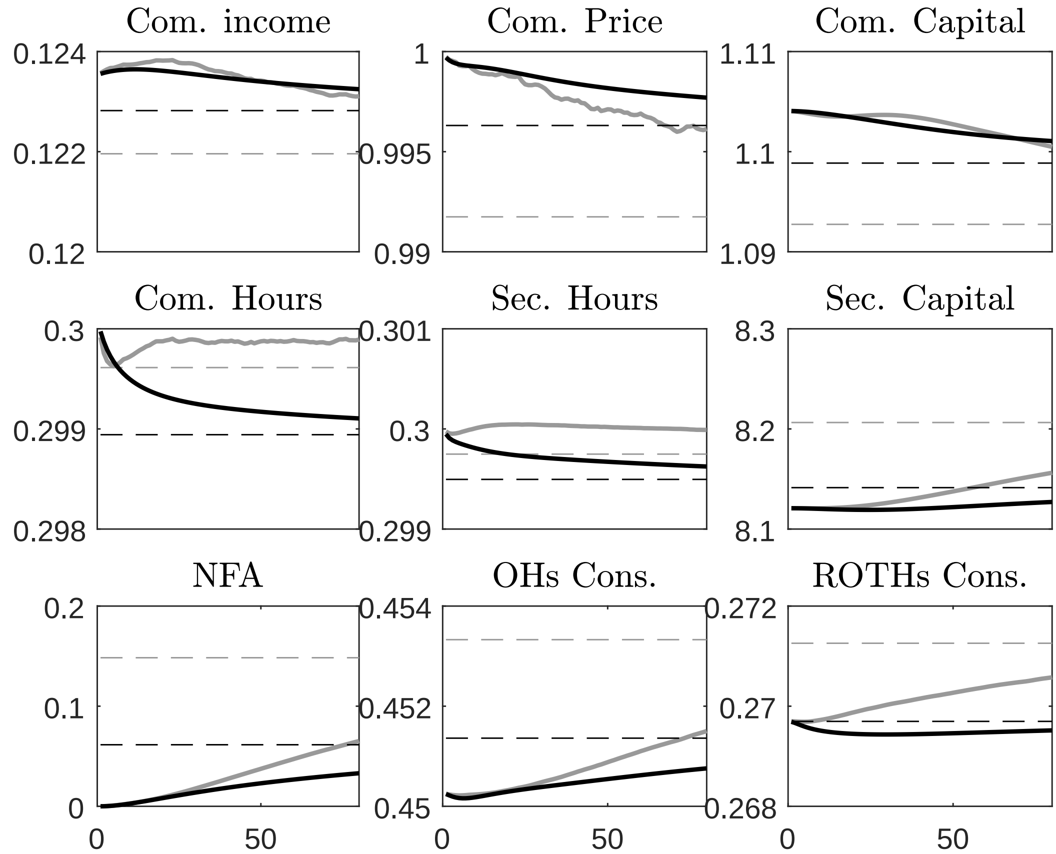
Note: Welfare costs of commodity supply fluctuations in the upper panel. Welfare costs of commodity price fluctuations in the lower panel. All numbers expressed in percentage points. Mode and 90% confidence bands reported in parenthesis.

welfare effects of consumption and hours fluctuations as long as the elasticity of factor supply is large enough and if households have a mean to transfer wealth across periods in the form of capital or bonds. Having access to these tools, OHs have the opportunity to benefit from option effects. Financially excluded households could also indirectly benefit from these effects if they translate into more physical capital and therefore increase the marginal productivity of labour and eventually wages.

In order to identify option effects, this paper evaluates the welfare effects of a pure commodity price shocks (see Table 3.4). It is modelled as a mean-preserving exogenous shock to real commodity prices (expressed in foreign currency) leaving activity in the foreign economy unaffected. This commodity price shock allows to focus on the effect of commodity price volatility, independent from their effects on the average level of commodity prices or economic activity abroad. This shock also significantly increases welfare of financially included households in the GTT version of the model. The impact is uncertain under the EHL assumption. Nevertheless, it shows that mean-preserving commodity price fluctuations might be welfare enhancing for some households and plausible sets of parameters. Also note that in the GTT variant, there is a small chance that commodity price fluctuations also increase excluded households welfare.

To understand these option effects, one very intuitive methodology would be to compare the average value of commodity incomes, capital stocks, foreign assets and consumption in the domestic economy driven by commodity price shocks, compared to its steady-state. If option effects are playing any role, consumption levels should be higher on average in the stochastic economy. However, this strategy might confuse option effects with precautionary savings. Indeed, when anticipating shocks, agent could decide to accumulate more assets to hedge against

Figure 3.2: Short-run effects of foreign commodity price shocks



Note: Effects of mean-preserving foreign commodity price fluctuations on domestic variables. Commodity price and net foreign assets in domestic currency. First economy mean conditional forecasts in grey. Forecasts converges to the first economy unconditional mean in dashed grey in the long run. Second economy transition to the SSS in black. SSS in dashed black. Computations based on the mode of estimated parameters. Horizon in quarters. GTT version of the model (EHL results are similar and not reported).

aggregate fluctuations. This paper therefore compares two alternative economies which all start at their deterministic steady-state (DSS). In the first economy, commodity prices are subject to exogenous shocks which generate business cycle fluctuations. In the second economy, no shock ever actually hits the economy, although agents anticipate commodity prices to fluctuate following the same law of motion as in the first economy. In this second economy, precautionary savings motives operate (because agents anticipate shocks) while option effects do not (because no shock actually ever hits the economy). All variables therefore simply converge towards what is usually referred to as their *stochastic steady-state (SSS)*. This experiment allows to distinguish the effects of precautionary savings from option effects by comparing this SSS with the mean of key variables in the first economy. Figure 3.2 reports the expected evolution of domestic variables in the first economy over 80 quarters, compared to the second. In the long run, forecasts for the first economy converge to their unconditional means while the second economy simply transitions towards its SSS. Table 3.5 reports the DSS, SSS and the unconditional mean of simulated variables in the first economy.

Table 3.5: Long-run effects of foreign commodity price shocks

	EHL model			**GTT model**		
	DSS	SSS	Mean	DSS	SSS	Mean
Commodity Income	0.1236	0.1225	0.1213	0.1236	0.1228	0.1220
Commodity Price	1.0000	0.9955	0.9860	1.0000	0.9963	0.9917
Commodity Output	0.1236	0.1231	0.1224	0.1236	0.1233	0.1219
Commodity Capital	1.1041	1.0964	1.0909	1.1041	1.0989	1.0927
Commodity Hours	0.0402	0.0400	0.0396	0.3000	0.2989	0.2996
Sec. Output	1.0000	0.9986	1.0015	1.0000	0.9998	1.0022
Sec. Capita	8.1208	8.1303	8.2357	8.1208	8.1414	8.2064
Sec. Hours	0.5598	0.5583	0.5579	0.3000	0.2995	0.2997
Net foreign assets	0.0000	0.0230	0.1555	0.0000	0.0615	0.1484
OHs consumption	0.4568	0.4566	0.4606	0.4503	0.4514	0.4533
ROTHs consumption	0.2632	0.2629	0.2649	0.2697	0.2697	0.2713

Note: Effects of a mean-preserving foreign commodity price shock on domestic variables. Commodity price and net foreign assets in domestic currency. DSS = deterministic steady-state, SSS = stochastic steady-state, Mean = unconditional mean of simulated variables in the stochastic economy. Computations based on the mode of estimated parameters.

Comparing the DSS and SSS, it is clear that precautionary motives encourage OHs to save in foreign assets and to accumulate secondary sector capital when anticipating commodity price fluctuations. However, OHs decide to hold less primary sector capital, probably for two reasons. On the one hand, holding primary sector capital is risky and it would therefore make sense to hold more foreign assets and domestic final good sector capital to hedge against commodity price fluctuation risks. On the other hand, accumulating foreign assets reduces the country risk premium, hence generating an appreciation of the domestic currency and a drop in commodity prices expressed in domestic currency units, thereby reducing the incentive to invest in the primary sector.[41] Comparing the mean of simulated variables with their SSS gives a picture of option effects. The average value of OHs and ROTHs consumption in the first economy is larger than their SSS indicating that mean-preserving commodity price fluctuations enable households to increase their average level of consumption. It seems that the extra average income generated (in the short-run) by commodity price fluctuations are invested in foreign assets and in secondary capital goods allowing to sustain higher domestically produced and imported consumption. This, in turn, decreases the country risk premium, fuels an appreciation of the

[41] In addition to option effects, some specific shocks could increase welfare through the precautionary savings motive. Since individual households do not internalise the impact of their net foreign assets position on the country risk premium, at the aggregate level, households could hold too few foreign assets. When some business cycle fluctuations trigger precautionary savings in the form of foreign assets, the gains from a lower risk premium could dominate the costs of aggregate fluctuations.

domestic currency and reduces the average value of commodity products. However, once OHs have accumulated foreign bonds and secondary sector capital, these extra assets are enough to sustain higher average consumption levels. ROTHs indirectly benefit from this strategy: the domestic currency appreciation reduces the real price of imported consumption goods, and the increase in physical capital raises labour productivity and therefore wages.

3.6.2 Welfare effects of monetary policy

This section has three objectives. First, it demonstrates that the benefits of monetary policy rules that respond aggressively to inflation are substantial and robust to parameter uncertainty for each type of agents. Responding to output growth has modest effects and is more likely to benefit financially excluded households. Second, it shows that pure inflation targeting with no interest rate smoothing is the optimal simple rule in the EHL framework. In the GTT version of the model, a combination of a strong anti inflation stance with moderate and strong response to output maximises the welfare of OHs and ROTHs, respectively. Third, it decomposes the source of the welfare gains associated to the optimal simple rule conditional on the occurrence of some types of specific shocks. It shows that most of the welfare gains associated to pure inflation targeting comes from mitigating the effects of demand shocks while this type of policy could be welfare decreasing in an economy driven by supply shocks. The optimal simple rule delivers important welfare gains but the welfare costs of business cycles remain substantial, especially for financially excluded households.

Welfare effects of alternative monetary policy rules

This section compares the welfare effects of five alternative simple rules to the baseline case where the Taylor rule is calibrated at the mode of its estimated parameters. First, it simulates a pure CPI-inflation targeting rule where $\tau_\pi = 3$ and $\tau_{\Delta y}$=$\tau_{\Delta s}$=0 and the interest rate smoothing parameter ρ_r is kept unchanged.[42] Pure inflation targeting has been widely recommended and is therefore a natural policy candidate. Second, it evaluates a pure domestic-inflation targeting rule with the same parameters values. Those two pure inflation targeting rules allow to contrast the effects of two relevant price index targets. Third, it gauges the impact of a faster policy response by lowering the smoothing parameter to $\rho_r = 0.5$. Central banks usually move their interest rates gradually for precautionary motives (for e.g. if the state of the economy is uncertain) and to maintain financial stability. In a context where agents are forward looking, monetary policies guiding future interest rates are capable to stabilise the economy. In the present model, half of households are hand to month consumers and it is interesting to evaluate the efficiency of interest rate smoothing. Fourth, it considers a muted response to output by

[42] Schmitt-Grohe and Uribe (2007) argue that policy coefficients larger than 3 or negative would be difficult to communicate to policy-makers or the public.

imposing that $\tau_{\Delta y}$=0. Finally, it examines a muted response to the exchange rate with $\tau_{\Delta s}$=0. Those last two rules are introduced in order to evaluate the desirability of interest rate responses to changes in real activity and to the exchange rate. Table 3.6 reports the premium (expressed as a fraction of steady-state consumption) that each domestic agents would be ready to give-up in order to be transferred from the baseline to one of the five alternative policy described above. Moreover, Tables 3.14 and 3.15 in the appendix show the impact of these policies on the simulated and theoretical variances of some key variables. In addition, Figures 3.5 and 3.6 depicts the welfare costs sensitivity to changes in each Taylor Rule coefficient.

Table 3.6: Welfare effects of alternative MP rules

	EHL model		**GTT model**	
CPI targeting	Cdt cost	Premium	Cdt cost	Premium
OHs	0.437	0.102	0.492	0.256
	(0.196 ; 0.744)	(0.055 ; 0.251)	(0.276 ; 0.817)	(0.165 ; 0.44)
ROTHs	2.049	0.398	0.974	0.352
	(1.711 ; 2.743)	(0.19 ; 0.964)	(0.602 ; 1.453)	(0.213 ; 0.63)
PPI targeting	Cdt cost	Premium	Cdt cost	Premium
OHs	0.416	0.125	0.469	0.281
	(0.191 ; 0.716)	(0.067 ; 0.276)	(0.263 ; 0.77)	(0.19 ; 0.485)
ROTHs	1.824	0.635	1.073	0.261
	(1.521 ; 2.473)	(0.363 ; 1.268)	(0.719 ; 1.539)	(0.112 ; 0.524)
Low int. rate smoothing	Cdt cost	Premium	Cdt cost	Premium
OHs	0.541	0.018	0.714	0.032
	(0.271 ; 0.924)	(-0.03 ; 0.061)	(0.445 ; 1.123)	(-0.054 ; 0.101)
ROTHs	2.278	0.163	1.229	0.08
	(1.81 ; 3.446)	(-0.044 ; 0.383)	(0.792 ; 1.874)	(0.002 ; 0.17)
Muted resp. to GDP	Cdt cost	Premium	Cdt cost	Premium
OHs	0.543	0.003	0.756	-0.01
	(0.265 ; 0.938)	(-0.006 ; 0.01)	(0.481 ; 1.156)	(-0.032 ; 0.002)
ROTHs	2.456	-0.018	1.359	-0.048
	(1.999 ; 3.714)	(-0.065 ; 0.009)	(0.899 ; 1.986)	(-0.092 ; -0.025)
Muted resp. to NEER	Cdt cost	Premium	Cdt cost	Premium
OHs	0.557	-0.007	0.731	0.014
	(0.277 ; 0.997)	(-0.06 ; 0.004)	(0.435 ; 1.168)	(-0.039 ; 0.061)
ROTHs	2.469	-0.026	1.247	0.055
	(1.985 ; 3.825)	(-0.242 ; 0.03)	(0.788 ; 1.889)	(-0.039 ; 0.16)

Note: The first column in each panels represents the conditional welfare costs of business cycles under an alternative Taylor rule. The second column shows the premium (as a fraction of consumption) that an agent would be ready to give to be transferred from the baseline to the economy operating with the alternative Taylor rule. Positive numbers show the agent prefers the alternative rule. All numbers expressed in percentage points. Mode and 90% confidence bands reported in parenthesis.

Pure CPI-inflation targeting Pure CPI-inflation targeting (with a much larger weight on CPI-inflation, no weight on output or the exchange rate and an unchanged smoothing parameter) could deliver substantial welfare gains for both types of households. These gains represents 0.1% and 0.26% of consumption for OHs in the EHL and GTT frameworks, respectively. ROTHs would be ready to renounce to 0.4% or 0.35% of consumption. This indicates that there is room for policy improvement through perusing a more aggressive inflation targeting policy. Most of these gains come from stabilising nominal variables. The drop in domestic good price inflation volatility reduces price dispersion and the input loss in the domestic distribution process. The reduction in wages inflation variance reduces hours dispersion. The drop in wages dispersion also reduces individual labour income volatility which benefits uninsured ROTHs. Moreover, this policy is likely to stabilise aggregate real wages which further mitigates ROTHs consumption fluctuations. In the GTT version of the model, pure inflation targeting also reduces unemployment volatility. In fact, unemployment fluctuations are mainly driven by demand factors (see the variance decomposition in Table 3.13). An aggressive interest rate response does a good job at mitigating demand shocks and therefore also reduces unemployment fluctuations. However, a more aggressive interest rate response could increase investment and OHs consumption volatility, as well as output. Overall, the welfare effects of pure CPI targeting are favourable for each type of agents. Figures 3.5 and 3.6 in the appendix show the welfare costs sensitivity to changes in the Taylor rule inflation coefficient for values between one and three. Increasing the inflation coefficient always raises welfare for each type of households over this interval but the gains slow as the value of this parameter increases.

Pure domestic-inflation targeting Pure domestic inflation targeting also sharply reduces the welfare costs of business cycles. The gains are similar to those obtained with pure CPI targeting. The underlying mechanisms are akin to those described above and the results are therefore not discussed in details.

Low interest rate smoothing Quick monetary policy response could bring welfare gains to financially excluded households. The effect amounts to 0.16% and 0.08% of consumption in the EHL and GTT versions of the model and is significant in the latter. The impact on included households welfare is not robust to parameter uncertainty in both models. Figures 3.5 and 3.6 show that an intermediate interest rate smoothing parameter (in the range of 0.75) would be optimal (fixing other Taylor Rule parameters at the mode). Faster monetary policy adjustments tend to reduce real variables volatility and to moderate the initial responses of inflation to a large range of shocks. However, this rule generates more persistence in inflation which eventually increases inflation volatility. With other Taylor rule parameters at their modes, reconciling these trade-offs requires an interest rate smoothing parameter of about 0.75, bellow its estimated value of 0.86. In particular, NAS and foreign shocks (including commodity price shocks) requires a faster monetary policy response while RAS and UIP shocks call for gradual interest rates movements.

Muted response to output growth Had the central bank muted its response to output, the welfare costs of business cycles would have been slightly larger for hand-to-mouth consumer. They would be ready to give-up 0.02 and 0.05% of their consumption level to avoid this policy in the EHL and GTT frameworks, respectively. The effect is significant in the latter. Accommodating output fluctuations makes unemployment and aggregate consumption more volatile. The variances of real labour income and wage inflation could also increase. Moreover, accommodating output fluctuations is unlikely to bring important gains in term of inflation stabilisation in a context where demand shocks are important drivers of business cycles. Figures 3.5 and 3.6 show conflicting preferences for OHs and ROTHs over the intensity of the monetary policy response to GDP growth deviation from its trend. ROTHs always favour the strongest response, while in the EHL framework, OHs fare better when monetary policy accommodates GDP fluctuations. In addition, although OHs prefer that the central bank accommodates GDP fluctuations caused by domestic supply shocks, ROTHs desire some intermediate level of output management. In fact, GDP growth stabilisation represents the main trade-off between OHs and ROTHs utility. From an utilitarian point of view, more emphasis on output stabilisation would be desirable since the gains for ROTHs outweighs OHs losses.

Muted response to changes in the NEER Had the central bank muted its response to the nominal exchange rate, the welfare costs of business cycles would have been slightly larger in the EHL version, but lower in the GTT context, for each types of households. However, none of these results are significant. One the one hand, Tables 3.14 and 3.15 show that a muted response to the NEER could increase the variance of nominal variables such as consumer prices, domestic prices, wages and the nominal exchange rate. On the other hand, this strategy could reduce ROTHs consumption volatility in the GTT framework. Engel (2011) argued that sticky prices in the importer currency (comparable to the model in this paper) generate inefficient deviations from the law of one price which justify some response to the import price index. However, it might not be necessary to respond to nominal exchange rate fluctuations beyond their impacts on the CPI. In particular, all external shocks (foreign shocks and SOE shocks) require a muted response to the exchange rate when the central banks already place a sufficient weight on the consumer price index.

Optimal simple rules

This subsection evaluates the optimal simple rule within the set of rules responding to CPI-inflation, output growth and the change in the NEER. The smoothing parameter ρ_r is restricted to the $[0,1[$ interval, the inflation and output parameters τ_π and $\tau_{\Delta y}$ are restricted to $[0,3]$ and the NEER parameter $\tau_{\Delta s}$ to $[0,1/2]$. Moreover, since monetary policy shocks decrease welfare, the optimal simple rule requires to set these shocks to zero.

Table 3.7: Optimal simple rules

	EHL model			**GTT model**		
Parameter	OH	ROTH	OSR	OH	ROTH	OSR
Interest rate smoothing	0	0	0	0	0	0
Inflation response	3	3	3	3	3	3
GDP growth response	0	0	0	0.5	3	2
NEER change response	0	0	0	0	0	0

Table 3.7 shows the optimal values of Taylor Rule coefficients in the EHL and GTT frameworks. In the EHL version, pure inflation targeting without interest rate smoothing is the optimal policy for each type of households. OHs would be ready to abandon 0.13% of their steady-state consumption level to implement the optimal simple rule. ROTHs would renounce to 0.62%. There is no trade-off between financially included and excluded households welfare. In this version of the model, business cycles generate similar types of risks for both categories of agents. Indeed, price and wage fluctuations generate an input loss in the production process and hours dispersion for OHs. Wage fluctuations cause hours and income dispersion for ROTHs. Income dispersion generates additional welfare costs to ROTHs, but the underlying mechanism remains wage inflation. Since pure CIP targeting can mitigate both price and wage inflation volatility, this policy is effective for both OHs and ROTHs. However, the welfare costs of business cycle fluctuations remain relatively large, even when the central follows the optimal monetary policy rule. Indeed, OHs and ROTHs would still agree to give-up 0.38% and 1.72% to edge against business cycles fluctuations, respectively. In the GTT framework, the optimal policy requires an additional response to GDP fluctuations. OHs welfare is maximised with a moderate response to GDP growth while ROTHs favour a stronger response. Search and matching frictions generate unemployment risks disproportionately borne by ROTHs (the search friction also imposes some rigidities on the firms). In this context, mitigating output fluctuations is welfare increasing, especially for ROTHs. From an utilitarian perspective, the output coefficient should be set to 2 to maximise aggregate welfare. OHs and ROTHs would be willing to pay a 0.25% and 0.4% premium to introduce the utilitarian optimal simple rule, respectively. Again, the welfare costs of business cycles remain substantial: they amount to 0.45% of consumption for OHs and to 0.84% for ROTHs.

Sources of welfare gains

This section further explores the sources of the welfare gains attained from following the optimal simple rules described above. It evaluates the desirability of these policies (compared

Table 3.8: Welfare effects of the EHL optimal simple rule

	EHL model		GTT model	
All shocks	Cdt cost	Premium	Cdt cost	Premium
OHs	0.381	0.131	0.423	0.264
	(0.155 ; 0.669)	(0.073 ; 0.299)	(0.222 ; 0.714)	(0.16 ; 0.473)
ROTHs	1.72	0.621	0.935	0.303
	(1.417 ; 2.297)	(0.372 ; 1.282)	(0.552 ; 1.391)	(0.163 ; 0.582)
AD	Cdt cost	Premium	Cdt cost	Premium
OHs	0.08	0.065	0.115	0.141
	(0.034 ; 0.264)	(0.021 ; 0.224)	(0.05 ; 0.25)	(0.061 ; 0.358)
ROTHs	0.243	0.348	0.132	0.23
	(0.118 ; 0.681)	(0.118 ; 1.079)	(0.058 ; 0.318)	(0.108 ; 0.501)
RAS	Cdt cost	Premium	Cdt cost	Premium
OHs	0.026	0.006	0.092	0.045
	(0.018 ; 0.037)	(-0.001 ; 0.013)	(0.068 ; 0.122)	(0.028 ; 0.067)
ROTHs	0.112	-0.015	0.037	-0.013
	(0.088 ; 0.156)	(-0.045 ; 0.006)	(0.017 ; 0.07)	(-0.039 ; 0.008)
NAS	Cdt cost	Premium	Cdt cost	Premium
OHs	0.144	0.026	0.092	0.043
	(0.112 ; 0.189)	(0.019 ; 0.037)	(0.071 ; 0.116)	(0.028 ; 0.058)
ROTHs	0.756	0.113	0.089	-0.001
	(0.616 ; 0.943)	(0.06 ; 0.182)	(0.037 ; 0.166)	(-0.015 ; 0.012)
SOE	Cdt cost	Premium	Cdt cost	Premium
OHs	-0.101	0.001	-0.077	-0.013
	(-0.184 ; -0.058)	(-0.007 ; 0.014)	(-0.136 ; -0.041)	(-0.032 ; 0)
ROTHs	0.078	0.001	-0.011	-0.007
	(0.035 ; 0.134)	(-0.028 ; 0.047)	(-0.048 ; 0.03)	(-0.046 ; 0.015)
AD*AS*	Cdt cost	Premium	Cdt cost	Premium
OHs	0.214	0.03	0.198	0.042
	(0.099 ; 0.394)	(0.017 ; 0.051)	(0.062 ; 0.37)	(0.027 ; 0.065)
ROTHs	0.532	0.183	0.656	0.099
	(0.367 ; 0.801)	(0.122 ; 0.283)	(0.35 ; 1.049)	(0.069 ; 0.141)

Note: The first panel shows the results for the baseline economy driven by all categories of shocks. Panels 2 to 6 represents economies affected by one particular group of shocks only. The first column in each panels represents the conditional welfare costs of business cycles under the optimal simple rule. The second column shows the premium that an agent would be ready to pay to be transferred from the baseline to the economy operating with the optimal simple rule. All numbers expressed in percentage points. Mode and 90% confidence bands reported in parenthesis.

Table 3.9: Welfare effects of the GTT optimal simple rule

	EHL model		**GTT model**	
All shocks	Cdt cost	Premium	Cdt cost	Premium
OHs	0.392	0.111	0.446	0.246
	(0.169 ; 0.69)	(0.059 ; 0.294)	(0.243 ; 0.731)	(0.148 ; 0.467)
ROTHs	1.734	0.592	0.841	0.392
	(1.456 ; 2.262)	(0.334 ; 1.295)	(0.478 ; 1.321)	(0.24 ; 0.691)
AD	Cdt cost	Premium	Cdt cost	Premium
OHs	0.08	0.063	0.106	0.152
	(0.036 ; 0.252)	(0.019 ; 0.236)	(0.047 ; 0.232)	(0.065 ; 0.377)
ROTHs	0.244	0.356	0.119	0.245
	(0.125 ; 0.612)	(0.111 ; 1.132)	(0.054 ; 0.287)	(0.113 ; 0.52)
RAS	Cdt cost	Premium	Cdt cost	Premium
OHs	0.034	-0.002	0.114	0.023
	(0.023 ; 0.048)	(-0.006 ; 0.002)	(0.085 ; 0.156)	(0.015 ; 0.035)
ROTHs	0.12	-0.022	0.01	0.016
	(0.095 ; 0.158)	(-0.049 ; -0.005)	(-0.017 ; 0.033)	(0.008 ; 0.026)
NAS	Cdt cost	Premium	Cdt cost	Premium
OHs	0.149	0.02	0.107	0.028
	(0.116 ; 0.199)	(0.015 ; 0.026)	(0.083 ; 0.131)	(0.021 ; 0.038)
ROTHs	0.762	0.099	0.075	0.014
	(0.627 ; 0.968)	(0.063 ; 0.15)	(0.034 ; 0.139)	(0.009 ; 0.019)
SOE	Cdt cost	Premium	Cdt cost	Premium
OHs	-0.099	-0.001	-0.081	-0.009
	(-0.188 ; -0.057)	(-0.007 ; 0.01)	(-0.142 ; -0.045)	(-0.029 ; 0.003)
ROTHs	0.08	-0.003	-0.031	0.011
	(0.044 ; 0.135)	(-0.029 ; 0.036)	(-0.084 ; 0.003)	(-0.024 ; 0.04)
AD*AS*	Cdt cost	Premium	Cdt cost	Premium
OHs	0.216	0.029	0.189	0.051
	(0.1 ; 0.395)	(0.017 ; 0.049)	(0.056 ; 0.358)	(0.033 ; 0.075)
ROTHs	0.542	0.166	0.643	0.107
	(0.367 ; 0.81)	(0.115 ; 0.26)	(0.353 ; 1.034)	(0.073 ; 0.16)

Note: The first panel shows the results for the baseline economy driven by all categories of shocks. Panels 2 to 6 represents economies affected by one particular group of shocks only. The first column in each panels represents the conditional welfare costs of business cycles under the optimal simple rule. The second column shows the premium that an agent would be ready to pay to be transferred from the baseline to the economy operating with the optimal simple rule. All numbers expressed in percentage points. Mode and 90% confidence bands reported in parenthesis.

to the baseline Taylor rule) conditionally on the occurrence of particular types of shock in the EHL and GTT versions of the model.

Table 3.8 reports the welfare gains associated to pure consumer price targeting with no interest rate smoothing in the EHL and GTT frameworks. It explores different scenarios where the economy is only affected by domestic aggregate demand shocks (AD), domestic real and nominal supply shocks (NAS and RAS), small open economy shocks (SOE) and foreign shocks (AD*, NAS* and RAS*); respectively. It shows that most of the gain associated to this policy comes from stabilising domestic demand shocks. This policy would also undoubtedly benefit economies driven by foreign shocks. However, there is a possibility that this policy decreases welfare in economies affected by real and nominal supply shocks (especially for ROTHs) or small open economy shocks. Although the potential welfare loss associated to pure inflation targeting in the event of domestic supply shocks or small open economy shocks highlights an important trade-off faced by the monetary policy, this effect is relatively small compared to the gains collected with this policy when the economy is affected by other types of shocks.

Table 3.9 shows the welfare gains associated to the GTT optimal simple rule. When the central bank places a high weight on inflation and output fluctuations, a similar conclusion applies. Indeed, most of the welfare gains come from mitigating the effects of aggregate demand shocks and this policy is also a better response to foreign shocks than the estimated Taylor Rule. However, there is no guarantee that this optimal simple rule would beat the baseline in economies driven by real supply shocks or small open economy shocks.

3.7 Conclusion

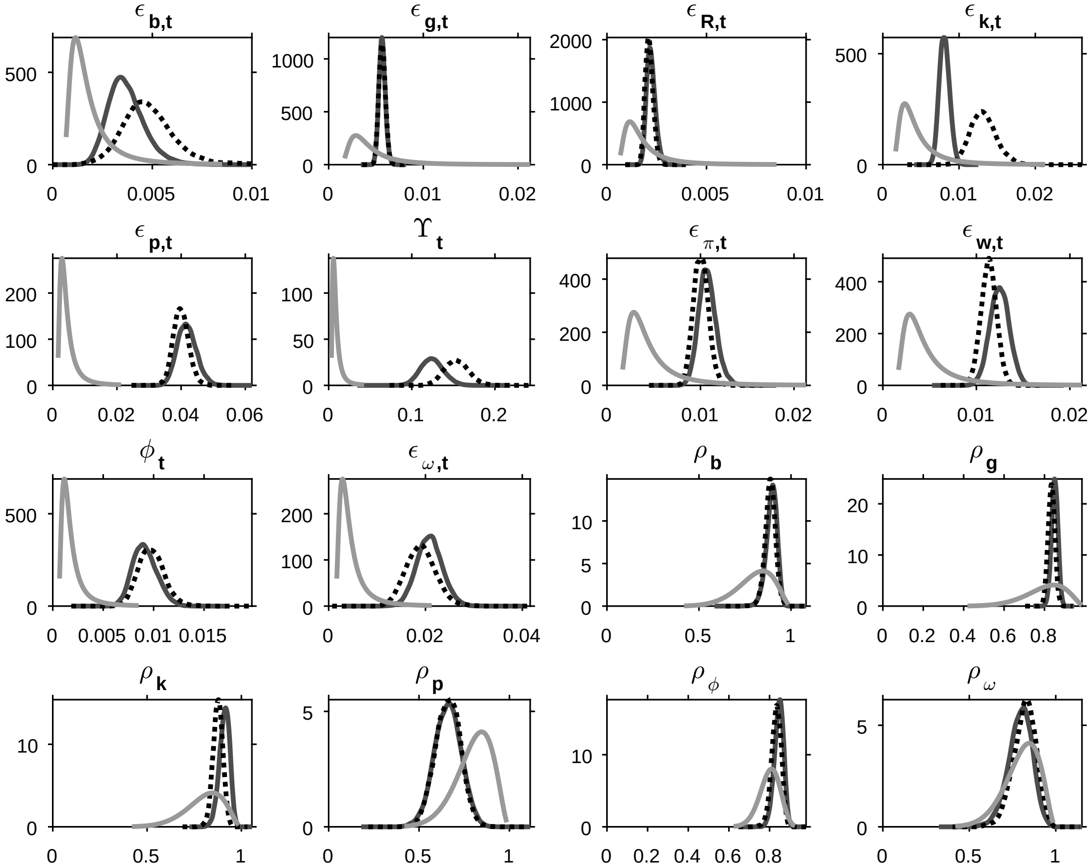
This paper measures the cost of business cycle fluctuations and the effects of alternative monetary policies in a small open emerging economy. South Africa is the country of choice. The model captures the key characteristics of a typical small open emerging economy: a large commodity sector exposed to developments in world commodity prices and imperfect capital and financial markets limiting the ability of some households to smooth consumption intertemporally and to insure against idiosyncratic risks in the labour market.

In this context, the welfare costs of business cycles are substantial in the emerging economy and they are much larger for households excluded from financial markets. Most of this welfare gap is driven by the exclusion from the insurance market. Moreover, option effects allow financially included households to benefit from some business cycle fluctuations - such as foreign commodity supply shocks - while it is unlikely to be the case for the other type of agents. This study also decomposes the welfare costs of business cycles into different types of disturbances classified according to their nature (demand vs supply) and origin (domestic vs foreign). It reveals that both domestic demand and supply shocks have important welfare effects hinting that there could be scope and limitation for more aggressive demand management policies. Foreign shocks also have economically meaningful welfare effects.

This paper then explores potential welfare gains from simple monetary policy rules to draw relevant policy recommendations. The welfare gains from a more aggressive anti-inflation policy are very important and robust to parameter uncertainty. Responding to output fluctuations is more likely to benefit excluded households. The optimal rule depends on the structure of the labour market. In the staggered monopolistic wage setting environment, the optimal policy consist in a immediate and strong response to inflation deviation from its target. In the search and matching friction with staggered wage bargaining framework, included households would benefit from a moderate response to output, while excluded households would prefer to place a large weight on output in addition to the strong anti-inflation stance. Financially excluded households gain more from appropriate monetary policies. Most of the welfare gains obtained with these optimal rules come from mitigating the effects of domestic demand shocks. While this strategy is also desirable in the event of foreign shocks, pure inflation targeting could be welfare decreasing in a small open emerging economy primarily driven by large domestic supply shocks. The welfare costs of business cycles remain substantial for each types of agents and particularly large for households excluded from the capital and financial markets.

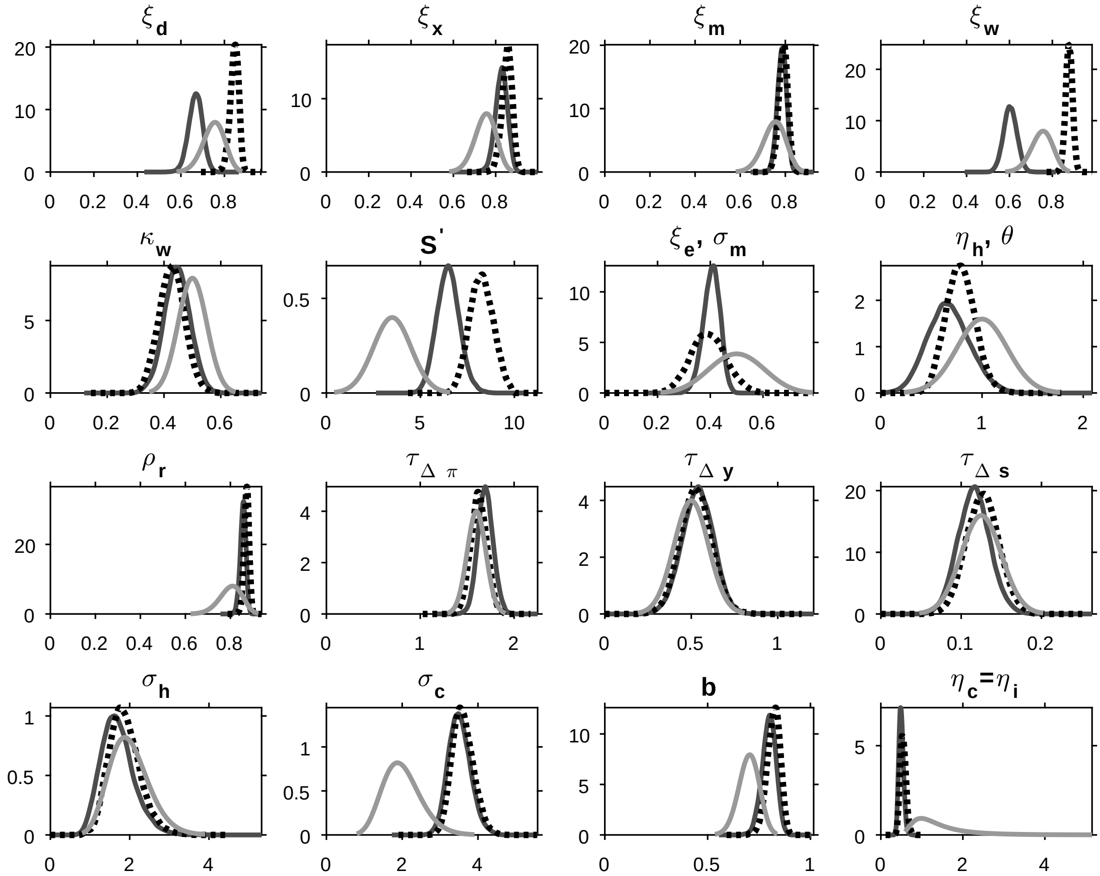
This paper raises different questions. First, what would be the role of self insurance for financially excluded households? Access to a simple storage technology - such as money - could have important implications. It could reduce the welfare costs of business cycles. However, recessions could still provoke prolonged periods of unemployment which could exhaust their wealth. Second, considering the fact that large welfare costs of business cycles remain, it would be interesting to consider the relative efficiency of fiscal policies. In particular, the welfare effects of commodity income management inspired from Norway's oil fund could be studied in this framework. Third, where does those large welfare gain come from? Are there any particular rigidities - real or nominal - that are responsible for those large estimates? In this context, it could be interesting to assess the impact of labour mobility.

Figure 3.3: Prior and posterior densities - shocks std and AR(1) coefficients



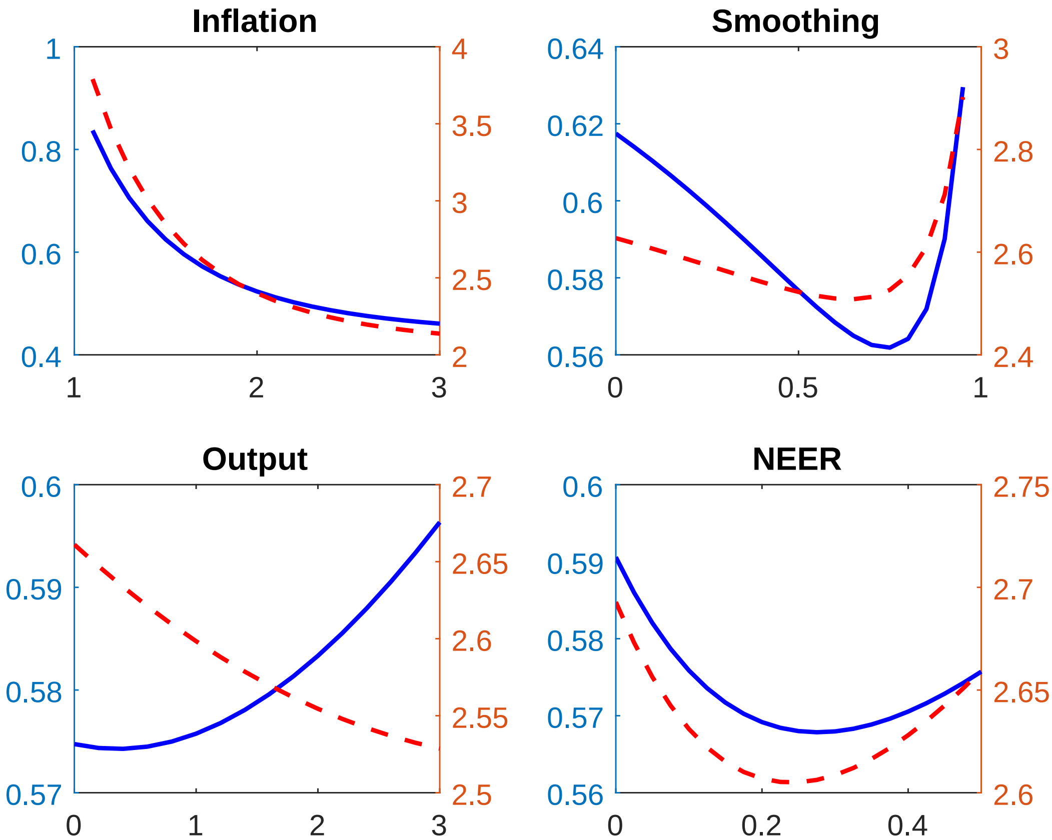
Note: Prior in grey, posterior for South Africa in the EHL version in solid black and in the GTT version in doted black. Shocks standard deviation (ε, Υ and ϕ) described in Table 3.1 and their persistence (ρ).

Figure 3.4: Prior and posterior densities - domestic parameters



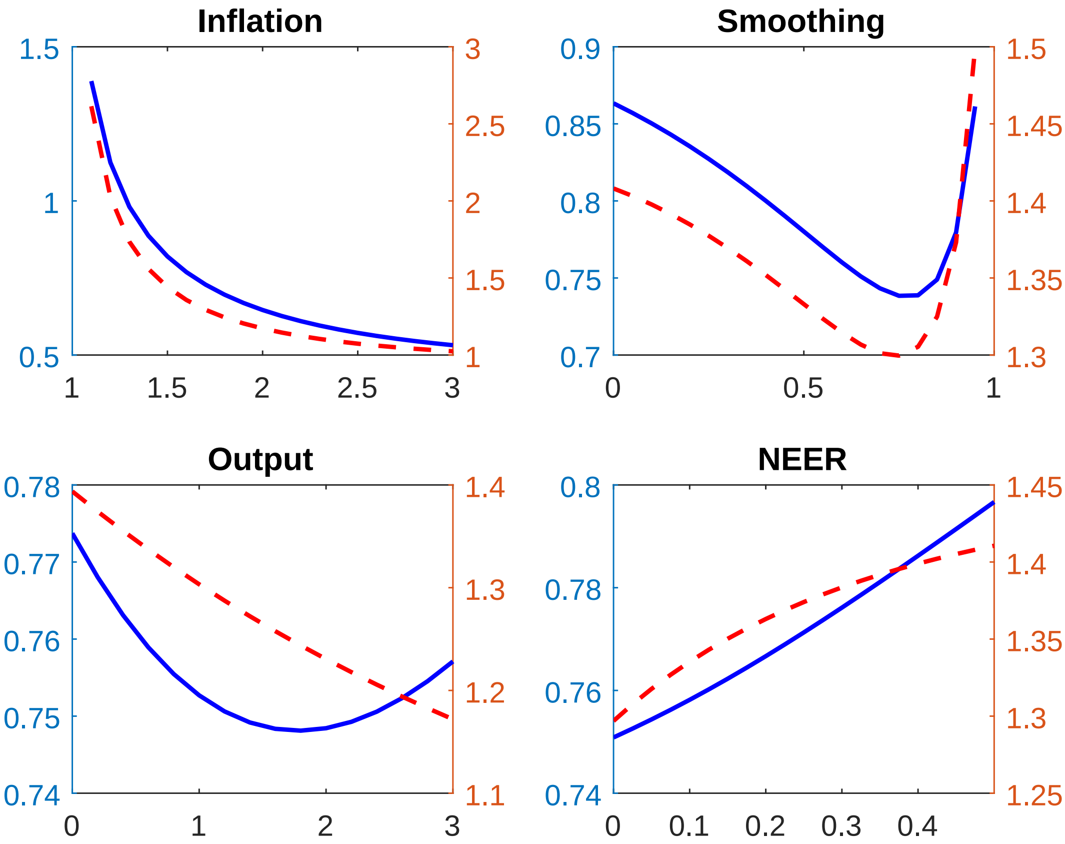
Note: Prior in grey, posterior for South Africa in the EHL version in solid black and in the GTT version in doted black.

Figure 3.5: Welfare Costs sensitivity to estimated Taylor Rule parameters: EHL model



Note: Welfare costs of business cycles for OHs (solid line, left axis) and ROTHs (dashed, right axis) as a function of univariate changes in inflation coefficient (top left), smoothing parameter (top right), output coefficient (bottom left) and exchange rate coefficient (bottom right). Other coefficients at their estimated mode.

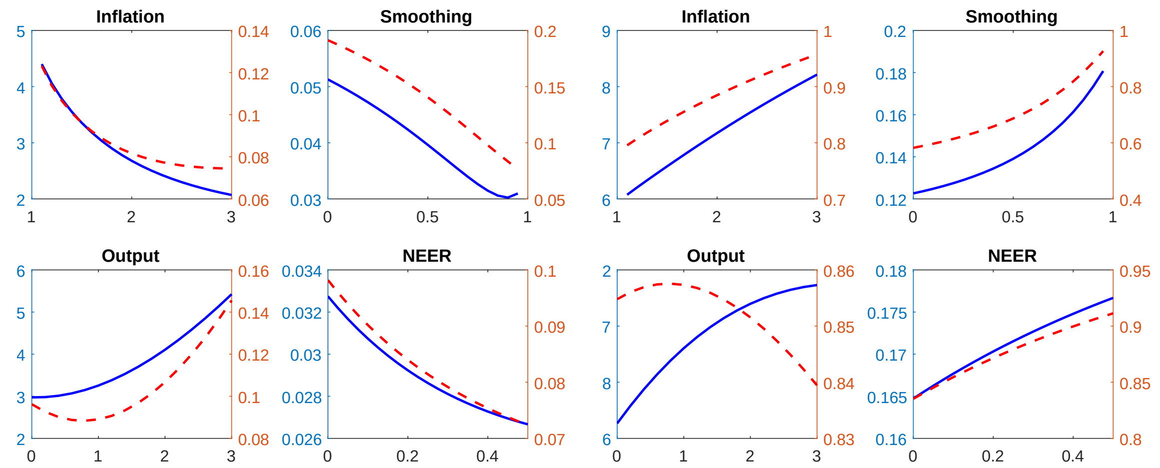
Figure 3.6: Welfare Costs sensitivity to estimated Taylor Rule parameters: GTT model



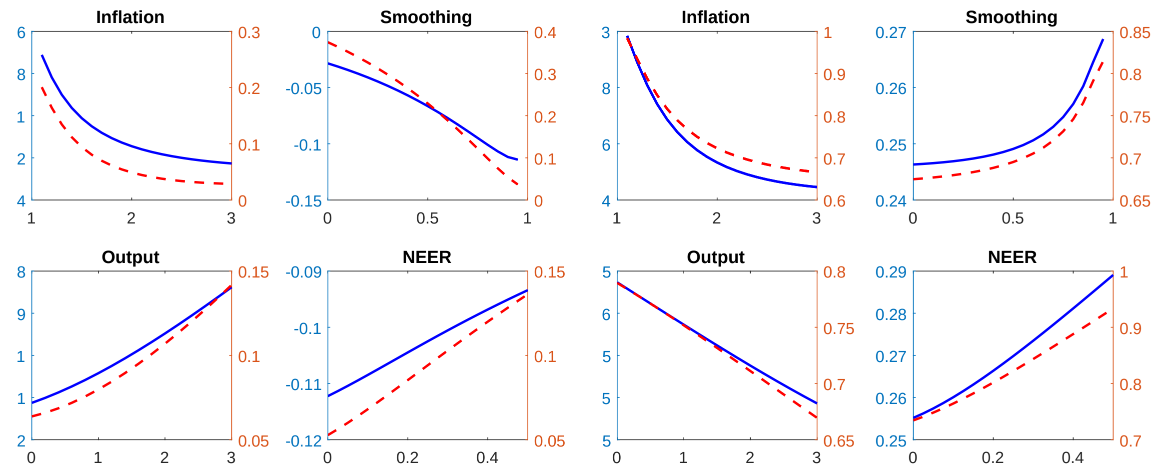
Note: Welfare costs of business cycles for OHs (solid line, left axis) and ROTHs (dashed, right axis) as a function of univariate changes in inflation coefficient (top left), smoothing parameter (top right), output coefficient (bottom left) and exchange rate coefficient (bottom right). Other coefficients at their estimated mode.

Figure 3.7: Welfare Costs sensitivity to estimated Taylor Rule parameters: EHL model

(a) Real aggregate supply shocks (b) Nominal aggregate supply shocks



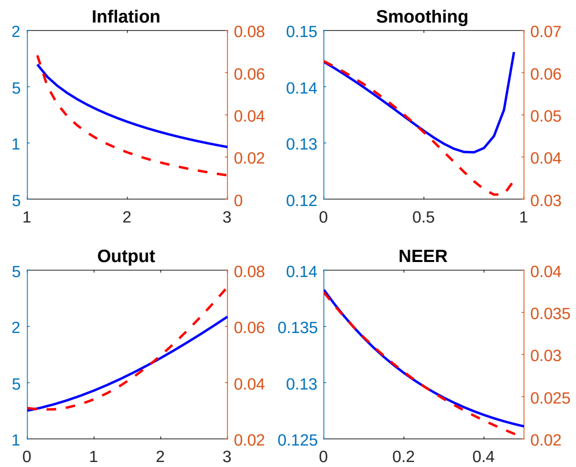
(c) Small open economy shocks (d) Foreign shocks



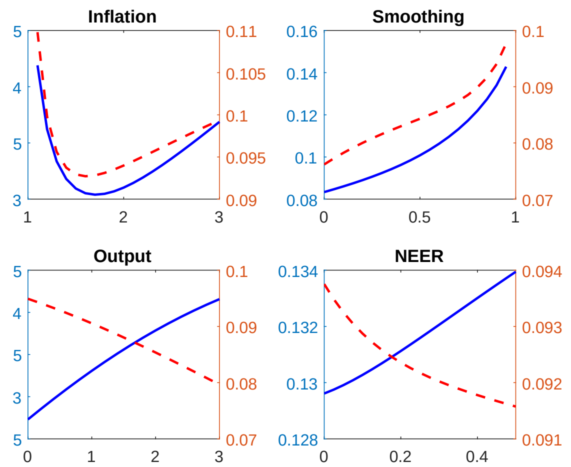
Note: Welfare costs of business cycles for OHs (solid line, left axis) and ROTHs (dashed, right axis) as a function of univariate changes in inflation coefficient (top left), smoothing parameter (top right), output coefficient (bottom left) and exchange rate coefficient (bottom right). Other coefficients at their optimal values. Economy exclusively driven by RAS shocks (a), NAS (b), SOE (c) and foreign shocks (d), respectively.

Figure 3.8: Welfare Costs sensitivity to estimated Taylor Rule parameters: GTT model

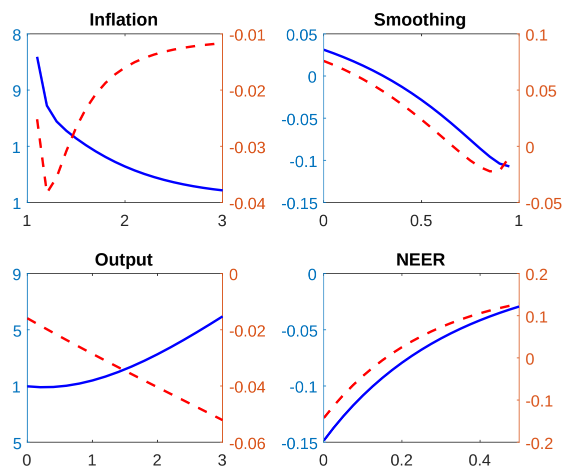
(a) Real aggregate supply shocks



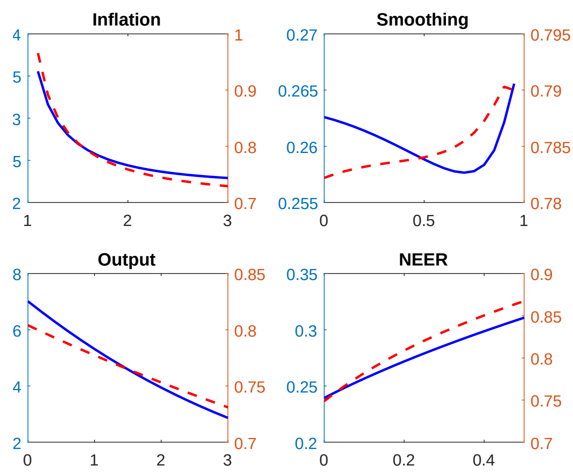
(b) Nominal aggregate supply shocks



(c) Small open economy shocks



(d) Foreign shocks



Note: Welfare costs of business cycles for OHs (solid line, left axis) and ROTHs (dashed, right axis) as a function of univariate changes in inflation coefficient (top left), smoothing parameter (top right), output coefficient (bottom left) and exchange rate coefficient (bottom right). Other coefficients at their optimal values. Economy exclusively driven by RAS shocks (a), NAS (b), SOE (c) and foreign shocks (d), respectively.

Table 3.10: Calibrated parameters and targets

Common para.	Description	Values
h	Hours devoted to work	0.3000
$\bar{\pi}$	Mean inflation rate	1.0150
R	Mean risk-free rate	1.0250
τ_k	Capital gain taxes	0.2000
τ_k	Capital gain taxes on bonds	0.0000
τ_w	Pay-roll tax	0.0500
τ_y	Labour income taxes	0.0300
τ_c	Value added tax	0.1400
δ	Capital depreciation rate	0.0200
α_p	Capital inc. share in prim. sector	0.3333
α_d	Capital inc. share in sec. sector	0.3333
$\frac{y^p}{y}$	Mining sector share in GDP	0.1100
ω_c	Imports share in consumption	0.3000
ω_i	Imports share in investment	0.5000
$\frac{a}{y}$	Foreign Debt to GDP ratio	0.0000
$\frac{g}{y}$	Gov. consumption to GDP ratio	0.1950
ϕ_a	Debt-elastic foreign interest rate	0.0010
$\kappa_d = \kappa_x = \kappa_m$	Price indexation	0.2000
ε_d	Mark-up final good	11.0000
EHL para.	Description	Values
ε_w	Mark-up labour market	11.0000
ω_h	Mining sector share in empl.	0.0670
GTT para.	Description	Values
δ_n	Job sepration rate	0.0700
$\frac{\varpi}{\bar{w}}$	Unempl. benefits ratio	0.4200
$\frac{U}{U+N}$	Unempl. Rate	0.1000
$\frac{N^p}{N^p+N^f}$	Mining sector share in empl.	0.0670
Foreign para.	Description	Values
λ^*	Mark-up final good	11.0000
λ^*_w	Mark-up labour market	11.0000
α^*	Capital income share	0.3000
β^*	Commodities income share	0.0500
ρ_{r*}	Foreign Monetary Policy	0.8500
τ^*_π	CB inflation response	1.8500
$\tau^*_{\Delta y}$	CB GDP growth response	0.2500
τ^*_y	CB GDP gap response	0.0000
κ^*	Indexation final good	0.2000

Table 3.11: Estimated shocks standard deviations and persistences

Std	Description	EHL Mode	Pst Std	Pst 5%	Pst 95%	GTT Mode	Pst Std	Pst 5%	Pst 95%	Pr Mean	Pr Std	Pr shape
ε_b^*	Wedge*	0.0022	0.0004	0.0017	0.0030	0.0021	0.0004	0.0017	0.0030	0.0020	0.0020	INV GAM.
ε_g^*	Gov*	0.0047	0.0013	0.0026	0.0069	0.0041	0.0013	0.0021	0.0063	0.0050	0.0050	INV GAM.
ε_R^*	Mon. Pol.*	0.0024	0.0001	0.0022	0.0027	0.0025	0.0001	0.0022	0.0027	0.0020	0.0020	INV GAM.
ε_k^*	Prod.*	0.0035	0.0003	0.0031	0.0040	0.0034	0.0003	0.0031	0.0040	0.0050	0.0050	INV GAM.
ε_p^*	Com. Sup.*	0.0113	0.0019	0.0092	0.0153	0.0120	0.0022	0.0097	0.0165	0.0050	0.0050	INV GAM.
Υ^*	Inv.*	0.0364	0.0100	0.0251	0.0557	0.0357	0.0133	0.0251	0.0607	0.0100	0.0100	INV GAM.
ε_π^*	Price*	0.0107	0.0007	0.0096	0.0119	0.0113	0.0008	0.0099	0.0124	0.0050	0.0050	INV GAM.
ε_w^*	Wage*	0.0083	0.0004	0.0077	0.0090	0.0081	0.0004	0.0075	0.0089	0.0050	0.0050	INV GAM.
$\tilde{\phi}$	UIP	0.0088	0.0012	0.0072	0.0111	0.0095	0.0013	0.0077	0.0118	0.0020	0.0020	INV GAM.
ε_ω	Trade	0.0208	0.0026	0.0164	0.0251	0.0187	0.0031	0.0139	0.0238	0.0050	0.0050	INV GAM.
ε_b	Wedge	0.0030	0.0009	0.0022	0.0051	0.0041	0.0013	0.0027	0.0068	0.0020	0.0020	INV GAM.
ε_g	Gov	0.0056	0.0003	0.0051	0.0062	0.0056	0.0003	0.0051	0.0062	0.0050	0.0050	INV GAM.
ε_R	Mon. Pol.	0.0021	0.0002	0.0019	0.0026	0.0021	0.0002	0.0018	0.0025	0.0020	0.0020	INV GAM.
ε_k	Prod.	0.0080	0.0007	0.0070	0.0092	0.0132	0.0017	0.0103	0.0159	0.0050	0.0050	INV GAM.
ε_p	Com. Sup.	0.0418	0.0030	0.0369	0.0466	0.0397	0.0024	0.0360	0.0439	0.0050	0.0050	INV GAM.
Υ	Inv.	0.1218	0.0137	0.1020	0.1470	0.1510	0.0144	0.1297	0.1767	0.0100	0.0100	INV GAM.
ε_π	Price	0.0106	0.0009	0.0092	0.0122	0.0100	0.0008	0.0087	0.0113	0.0050	0.0050	INV GAM.
ε_w	Wage	0.0125	0.0010	0.0108	0.0142	0.0113	0.0008	0.0099	0.0127	0.0050	0.0050	INV GAM.
AR(1)	Description	EHL Mode	Pst Std	Pst 5%	Pst 95%	GTT Mode	Pst Std	Pst 5%	Pst 95%	Pr Mean	Pr Std	Pr shape
ρ_b^*	Wedge*	0.876	0.018	0.836	0.896	0.882	0.018	0.843	0.901	0.800	0.100	BETA
ρ_k^*	Prod.*	0.970	0.011	0.949	0.984	0.980	0.013	0.952	0.993	0.800	0.100	BETA
ρ_p^*	Com. Sup.*	0.939	0.011	0.918	0.953	0.934	0.011	0.913	0.948	0.800	0.100	BETA
$\rho_{\Upsilon*}$	Inv.*	0.720	0.044	0.630	0.774	0.709	0.049	0.605	0.767	0.800	0.100	BETA
$\rho\phi$	UIP	0.851	0.023	0.808	0.882	0.839	0.024	0.795	0.872	0.800	0.050	BETA
ρ_ω	Trade	0.808	0.069	0.682	0.905	0.836	0.066	0.713	0.927	0.800	0.100	BETA
ρ_b	Wedge	0.916	0.030	0.846	0.941	0.902	0.028	0.840	0.932	0.800	0.100	BETA
ρ_k	Prod.	0.917	0.027	0.865	0.954	0.877	0.026	0.834	0.919	0.800	0.100	BETA
ρ_p	Com. Sup.	0.666	0.073	0.540	0.780	0.667	0.069	0.543	0.770	0.800	0.100	BETA
MA(1)	Description	EHL Mode	Pst Std	Pst 5%	Pst 95%	GTT Mode	Pst Std	Pst 5%	Pst 95%	Pr Mean	Pr Std	Pr shape
ρ_ω^{MA}	Trade	0.885	0.080	0.723	0.968	0.857	0.100	0.660	0.963	0.800	0.100	BETA
ρ_p^{MA*}	Com. Sup.	0.365	0.057	0.274	0.462	0.369	0.057	0.275	0.460	0.500	0.100	BETA

Table 3.12: Estimated parameters

Domestic	Description	EHL Mode	Pst Std	Pst 5%	Pst 95%	GTT Mode	Pst Std	Pst 5%	Pst 95%	Pr Mean	Pr Std	Pr shape
ξ_d	Calvo final good	0.676	0.032	0.615	0.718	0.848	0.020	0.813	0.877	0.750	0.050	BETA
ξ_m	Calvo impots	0.790	0.020	0.752	0.817	0.796	0.020	0.759	0.824	0.750	0.050	BETA
ξ_x	Calvo exports	0.825	0.029	0.780	0.873	0.856	0.024	0.813	0.893	0.750	0.050	BETA
ξ_w	Calvo wages	0.606	0.031	0.553	0.655	0.873	0.016	0.852	0.905	0.750	0.050	BETA
κ_w	wage indexation	0.443	0.046	0.372	0.523	0.430	0.045	0.351	0.499	0.500	0.050	BETA
$\tilde{S}''$	Invest. adj. cost	6.407	0.602	5.460	7.430	8.196	0.615	7.246	9.277	3.500	1.000	NORM
η_f	Exports price elast.	0.444	0.053	0.364	0.537	0.482	0.063	0.383	0.586	1.500	1.000	INV G.
$\eta_c = \eta_i$	Imports price elast.	0.497	0.057	0.401	0.585	0.547	0.070	0.422	0.649	1.500	1.000	INV G.
ρ_r	Int. rate smooth.	0.860	0.013	0.835	0.877	0.874	0.011	0.854	0.890	0.800	0.050	BETA
τ_π	CB inflation resp.	1.690	0.082	1.560	1.829	1.620	0.086	1.482	1.765	1.600	0.100	NORM
$\tau_{\Delta s}$	CB NEER resp.	0.116	0.020	0.083	0.148	0.126	0.020	0.093	0.160	0.125	0.025	NORM
$\tau_{\Delta y}$	CB GDP resp.	0.534	0.090	0.390	0.684	0.532	0.091	0.378	0.675	0.500	0.100	NORM
ρ_g	Gov. cons. smooth.	0.853	0.016	0.824	0.877	0.836	0.017	0.806	0.861	0.800	0.100	BETA
ξ_e	Labour hoarding	0.410	0.032	0.353	0.457					0.500	0.100	BETA
η_h	Labour mobility	0.650	0.207	0.323	1.005					1.000	0.250	NORM
θ	Vacancy costs elast.					0.768	0.143	0.546	1.012	1.000	1.000	GAM
σ_m	Match. elast. to un.					0.393	0.066	0.280	0.500	0.500	0.100	BETA
Utility	**Description**	**EHL Mode**	**Pst Std**	**Pst 5%**	**Pst 95%**	**GTT Mode**	**Pst Std**	**Pst 5%**	**Pst 95%**	**Pr Mean**	**Pr Std**	**Pr shape**
b	External habbits	0.798	0.034	0.742	0.853	0.824	0.032	0.771	0.873	0.700	0.050	BETA
σ_c	Cons. subst. elast.	3.369	0.293	3.024	3.977	3.435	0.281	3.153	4.069	2.000	0.500	GAM
σ_l	Labour sup. elast.	1.601	0.418	1.010	2.344	1.779	0.392	1.231	2.485	2.000	0.500	GAM
Foreign	**Description**	**EHL Mode**	**Pst Std**	**Pst 5%**	**Pst 95%**	**GTT Mode**	**Pst Std**	**Pst 5%**	**Pst 95%**	**Pr Mean**	**Pr Std**	**Pr shape**
σ_d^*	Commodity subst.	0.185	0.028	0.155	0.243	0.191	0.030	0.160	0.256	0.250	0.100	BETA
ξ^*	Calvo final good	0.749	0.025	0.704	0.786	0.738	0.026	0.697	0.781	0.750	0.050	BETA
ξ_w^*	Calvo wages	0.734	0.025	0.688	0.770	0.738	0.024	0.695	0.775	0.750	0.050	BETA
κ_w^*	wage indexation	0.382	0.039	0.319	0.446	0.377	0.038	0.317	0.443	0.500	0.050	BETA
$\tilde{S}_*''$	Invest. adj. cost	3.586	0.842	2.547	5.179	3.382	0.926	2.512	5.244	3.500	1.500	NORM
ρ_g^*	Gov. cons. Smooth.	0.861	0.048	0.777	0.938	0.889	0.047	0.807	0.957	0.800	0.100	BETA

Table 3.13: Variance Decomposition

EHL Variables	Symbols	AD*	RAS*	NAS*	AD	R-AS	N-AS	SOE
GDP	Y_t	3.16	13.54	2.08	24.11	41.62	7.29	8.19
Consumptio	C_t	2.55	39.35	4.78	31.88	11.42	4.77	5.26
OHs cons.	C_t^o	0.99	22.95	2.46	40.10	20.37	4.47	8.65
ROTHs cons.	C_t^r	4.57	43.12	5.88	19.68	7.68	9.81	9.26
Hours	H_t	4.74	13.49	2.33	26.34	22.10	10.15	20.85
Labour income	$\bar{w}$	4.54	20.35	2.04	16.37	22.19	21.92	12.58
Wage inflation	π_t^w	1.18	4.04	0.88	16.92	1.90	72.03	3.06
CPI inflation	π_t^c	1.45	0.96	9.39	23.93	13.16	37.97	13.14
Domestic inflation	π_t	1.32	3.49	0.28	22.69	18.21	48.20	5.78
NEER (diff)	dS_t	6.07	5.01	1.08	5.73	0.89	0.32	80.90
Interest rate	R_t	2.53	1.44	1.71	57.41	8.64	6.20	22.09
GTT Variables	**Symbols**	**AD***	**RAS***	**NAS***	**AD**	**R-AS**	**N-AS**	**SOE**
GDP	Y_t	3.13	13.82	1.54	21.23	44.66	5.85	9.78
Consumptio	C_t	1.88	33.84	3.53	39.89	11.23	5.27	4.37
OHs cons.	C_t^o	0.95	19.27	1.63	51.77	16.72	4.23	5.44
ROTHs cons.	C_t^r	2.88	40.94	5.36	11.27	2.23	32.26	5.07
Unemployment	U_t	4.31	19.78	1.65	41.55	4.65	22.73	5.32
Hours in prim. sect.	H_t^p	7.83	39.23	3.07	16.54	9.87	1.64	21.83
Hours in sec. sect.	H_t^f	0.52	0.47	0.16	6.95	60.52	18.85	12.53
Prim. sect. lab. inc.	$\bar{w}_t^p$	3.95	25.81	1.04	11.75	23.05	28.23	6.18
Sec. sect. lab. inc.	$\bar{w}_t^f$	0.32	1.02	0.41	3.34	13.62	78.11	3.19
Prim. sect. wage infl.	$\pi_t^{\bar{w}.p}$	3.88	14.58	1.05	7.94	2.30	63.28	6.97
Final sect. wage infl.	$\pi_t^{\bar{w}.f}$	0.96	2.21	0.87	14.93	4.49	74.08	2.45
CPI inflation	π_t^c	1.87	0.51	9.48	25.83	10.35	39.32	12.65
Final good infl.	π_t	1.46	3.26	0.16	25.81	14.54	51.32	3.43
NEER (diff)	dS_t	5.77	4.49	1.00	5.41	0.45	0.20	82.68
Interest rate	R_t	3.48	1.05	1.58	56.41	7.61	5.44	24.45
Foreign Variables	**Symbols**	**AD***	**RAS***	**NAS***	**AD**	**R-AS**	**N-AS**	**SOE**
US GDP	Y_t^*	27.06	54.27	18.67	-	-	-	-
US inflation	π_t^*	12.82	3.36	83.82	-	-	-	-
US interest rate	R_t^*	59.60	7.79	32.62	-	-	-	-
Commodity price	γ_t^{p*}	10.24	82.28	7.50	-	-	-	-

Note: Variables in percentage diviation from steady-state. Stars stand for foreign shocks. See Table 3.1 for a description of the shocks classification. South African variable in the EHL version the first panel. GTT in the second and foreign variable in the third. Variance decomposition for the 5 years horizon.

Table 3.14: Standard deviation of simulated variables in alternative monetary policy rules

		Baseline	**Pure CPI targeting**			**Low int. rate smoothing**			**Muted resp. to output**			**Muted resp. to NEER**		
EHL Variables		100sd	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%
GDP	Y_t	2.41	4.99	1.21	7.05	-6.68	-9.28	-4.92	2.34	1.55	3.17	1.29	0.60	2.59
Consumptio	C_t	3.04	1.49	-4.67	6.01	-9.90	-13.34	-6.62	1.83	1.09	2.56	1.35	0.66	2.41
OHs cons.	C_t^o	3.13	5.59	-0.75	10.03	-5.27	-9.68	-2.18	1.93	1.15	2.63	1.04	0.47	2.01
ROTHs cons.	C_t^r	4.33	-3.29	-6.60	-0.58	-8.45	-11.10	-6.09	0.85	0.47	1.42	1.06	0.42	2.03
Hours	H_t	3.31	-8.75	-12.35	-5.71	-9.91	-14.37	-6.91	0.32	-0.51	1.34	1.21	0.42	2.16
Labour income	$\bar{w}$	3.66	-1.41	-4.14	0.54	-8.89	-10.50	-7.19	0.90	0.37	1.52	1.59	0.83	2.67
Wage inflation	π_t^w	1.31	-6.45	-9.76	-4.20	2.91	0.72	4.92	0.25	-0.05	0.96	0.98	0.38	2.38
CPI inflation	π_t^c	0.85	-15.79	-21.13	-11.95	9.96	6.25	13.83	-1.07	-2.24	0.27	2.18	1.11	4.92
Domestic inflation	π_t	1.07	-9.93	-13.70	-6.94	5.34	1.91	8.46	-0.24	-1.10	0.93	1.15	0.38	3.07
NEER (diff)	dS_t	5.19	-1.68	-3.81	0.62	-8.34	-11.24	-4.21	-0.45	-0.92	-0.09	3.77	2.60	5.00
Interest rate	R_t	0.71	9.99	1.86	18.39	80.97	60.07	102.71	2.87	1.36	4.47	-0.98	-5.53	4.11
GTT Variables		100sd	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%
GDP	Y_t	2.43	5.20	1.16	8.47	-4.37	-7.48	1.94	1.42	0.84	2.23	1.27	0.43	3.43
Consumptio	C_t	3.03	2.37	-3.59	7.81	-7.70	-10.05	-5.12	1.25	0.75	1.96	1.06	0.52	2.09
OHs cons.	C_t^o	3.37	3.25	-4.74	11.95	-8.02	-10.42	-5.42	1.34	0.60	2.27	1.80	0.95	3.28
ROTHs cons.	C_t^r	3.36	-0.09	-2.26	1.04	-0.11	-5.98	7.85	0.69	0.20	1.24	-0.81	-1.30	-0.31
Unemployment	U_t	20.92	-17.28	-23.26	-10.89	17.97	5.46	35.13	2.95	1.62	4.77	3.82	1.76	6.55
Hours in prim. sect.	H_t^p	5.74	0.44	-0.57	1.04	0.56	-0.08	1.70	0.05	-0.06	0.17	0.06	-0.13	0.40
Hours in sec. sect.	H_t^f	2.44	-1.09	-2.84	0.70	-0.85	-3.37	6.04	-0.30	-0.59	0.02	-0.16	-0.59	0.69
Prim. sect. lab. inc.	$\bar{w}_t^p$	4.69	0.27	-3.15	1.94	4.16	0.91	9.31	1.44	0.90	2.15	0.90	0.37	1.84
Sec. sect. lab. inc.	$\bar{w}_t^f$	3.54	-1.10	-5.63	2.45	6.73	0.49	14.48	2.05	1.26	3.21	0.91	-0.04	1.73
Prim. sect. wage infl.	$\pi_t^{\bar{w},p}$	1.38	-3.67	-5.85	-2.30	2.43	1.15	4.46	0.45	0.22	0.86	0.56	0.15	1.36
Final sect. wage infl.	$\pi_t^{\bar{w},f}$	1.27	-4.84	-7.99	-3.01	2.29	0.38	4.21	0.35	0.04	0.94	0.73	0.31	1.67
CPI inflation	π_t^c	0.86	-15.09	-19.93	-11.83	10.90	6.77	16.36	-0.20	-0.97	0.79	1.85	0.78	4.09
Final good infl.	π_t	1.07	-9.93	-13.94	-7.02	5.52	2.32	9.52	0.07	-0.62	0.86	0.98	0.29	2.52
NEER (diff)	dS_t	5.33	-2.22	-4.55	0.33	-9.18	-11.84	-5.45	-0.13	-0.48	0.09	3.61	2.62	4.51
Interest rate	R_t	0.65	17.13	8.54	25.76	104.47	84.36	126.11	3.64	1.44	6.56	-1.84	-6.61	2.74

Note: 100sd = 100 times the standard deviation of variables expressed in deviation from steady-state. Diff = percentage change in variables standard deviation with alternative policy rules compared to the baseline. Simulated variables over 92 periods.

Table 3.15: Theoretical standard deviation in alternative monetary policy rules

		Baseline	Pure CPI targeting			Low int. rate smoothing			Muted resp. to output			Muted resp. to NEER		
EHL Variables		100sd	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%
GDP	Y_t	3.36	1.30	-2.20	3.26	-4.59	-6.29	-3.33	1.80	1.19	2.33	0.20	-0.22	1.05
Consumptio	C_t	6.91	-0.15	-1.66	0.89	-2.12	-4.01	-1.23	0.75	0.44	1.14	-0.13	-0.29	0.21
OHs cons.	C_t^o	7.59	0.85	-0.42	1.87	-0.96	-2.38	-0.32	0.76	0.45	1.18	-0.14	-0.26	0.13
ROTHs cons.	C_t^r	7.11	-2.02	-3.79	-1.12	-3.42	-5.38	-2.36	0.42	0.23	0.71	-0.03	-0.24	0.44
Hours	H_t	4.30	-6.07	-8.84	-3.91	-7.15	-10.50	-5.00	0.29	-0.26	1.01	0.08	-0.31	0.68
Labour income	$\bar{w}$	4.55	-3.36	-6.05	-1.60	-7.26	-9.05	-5.63	0.83	0.47	1.36	0.11	-0.36	0.86
Wage inflation	π_t^w	1.31	-7.95	-11.60	-5.76	1.97	-0.35	4.26	-0.26	-0.54	0.18	0.62	0.06	2.27
CPI inflation	π_t^c	0.91	-17.78	-23.09	-14.02	7.61	3.65	10.91	-1.72	-2.56	-0.75	1.71	0.69	4.42
Domestic inflation	π_t	1.17	-11.94	-15.64	-9.12	2.79	-0.42	5.55	-0.90	-1.52	-0.13	0.76	0.06	2.76
NEER (diff)	dS_t	5.35	-1.04	-3.10	1.22	-7.56	-10.55	-3.19	-0.45	-0.91	-0.13	3.60	2.49	4.80
Interest rate	R_t	0.72	12.39	2.18	21.23	84.91	61.50	104.58	1.84	-0.55	4.45	-0.26	-4.82	4.93
GTT Variables		100sd	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%	Diff	5%	95%
GDP	Y_t	3.33	0.12	-3.33	2.69	0.36	-1.70	3.61	-0.08	-0.55	0.40	0.44	-0.24	1.88
Consumptio	C_t	6.50	0.11	-1.64	1.23	-0.91	-2.59	-0.06	0.22	0.02	0.61	-0.04	-0.31	0.39
OHs cons.	C_t^o	7.36	1.39	-1.21	3.25	-0.18	-1.80	1.33	-0.01	-0.46	0.50	-0.02	-0.56	0.79
ROTHs cons.	C_t^r	6.38	-1.45	-2.37	-0.76	-1.14	-3.01	0.58	0.73	0.44	1.26	-0.48	-0.73	-0.30
Unemployment	U_t	28.16	-12.68	-17.48	-8.43	6.77	-0.44	17.04	1.02	0.23	1.91	0.15	-1.59	3.17
Hours in prim. sect.	H_t^p	6.28	1.11	-0.03	1.89	0.16	-0.24	0.91	-0.03	-0.16	0.08	0.14	-0.05	0.48
Hours in sec. sect.	H_t^f	3.48	1.38	0.23	3.40	0.71	-1.03	5.50	-0.87	-1.56	-0.50	-0.73	-1.56	-0.21
Prim. sect. lab. inc.	$\bar{w}_t^p$	5.68	-0.57	-2.33	0.75	0.36	-0.79	2.47	1.60	0.94	2.58	0.41	0.08	1.09
Sec. sect. lab. inc.	$\bar{w}_t^f$	4.43	-2.11	-4.61	-0.39	1.33	-2.16	6.30	2.03	1.25	3.31	-0.18	-0.76	0.29
Prim. sect. wage infl.	$\pi_t^{\bar{w}.p}$	1.35	-4.69	-7.32	-3.11	1.95	0.41	4.59	0.26	0.06	0.56	0.21	-0.17	1.27
Final sect. wage infl.	$\pi_t^{\bar{w}.f}$	1.29	-6.06	-9.33	-4.03	1.15	-0.74	3.52	-0.08	-0.33	0.24	0.51	0.07	1.46
CPI inflation	π_t^c	0.91	-17.52	-22.03	-13.96	7.59	2.79	12.54	-0.65	-1.27	-0.06	1.66	0.59	4.01
Final good infl.	π_t	1.14	-12.09	-15.81	-9.17	2.32	-1.09	6.25	-0.31	-0.86	0.22	0.90	0.10	2.50
NEER (diff)	dS_t	5.47	-1.68	-4.04	0.89	-8.49	-11.26	-4.62	-0.14	-0.54	0.12	3.38	2.45	4.31
Interest rate	R_t	0.66	13.36	5.29	21.06	105.71	83.65	126.40	1.11	-1.58	4.20	-1.29	-6.65	3.43

Note: 100sd = 100 times the standard deviation of variables expressed in deviation from steady-state. Diff = percentage change in variables standard deviation with alternative policy rules compared to the baseline. Unconditional standard deviations.

3.8 Appendix: Complete set of equilibrium conditions

This appendix provides the reader with the details on how to derive the complete set of equilibrium conditions for households, firms and the labour market (for both EHL and GTT versions). In addition, for some equations, it shows how they are implemented in *Dynare*. Those equations have been expressed following the convention that lower case variables denote the stationarized equivalent of their upper case counterparts. In particular, some variables have a nominal trend because of the positive inflation rate target.

3.8.1 Households

The consumption demand functions for the domestic and the imported goods are given by maximising the consumption basket under a fixed consumption spendings:

$$C_t^d = (1-\omega_c)\left[\frac{P_t}{P_t^C}\right]^{-\eta_c} C_t, \tag{3.8.1}$$

$$C_t^m = \omega_c\left[\frac{P_t^m}{P_t^C}\right]^{-\eta_c} C_t, \tag{3.8.2}$$

where P_t is the domestic good price, P_t^m the imported good price and P_t^c represents the Consumer price index (CPI) and is given by:

$$P_t^c = \left[(1-\omega_c)(P_t)^{1-\eta_c} + \omega_c(P_t^m)^{1-\eta_c}\right]^{1/(1-\eta_c)}.$$

which is made stationary as follows:

$$(\pi_t^c)^{1-\eta_c} = (1-\omega_c)\left(\pi_t\frac{P_{t-1}}{P_{t-1}^c}\right)^{1-\eta_c} + \omega_c\left(\pi_t^m\frac{P_{t-1}^m}{P_{t-1}^c}\right)^{1-\eta_c} \tag{3.8.3}$$

where gross inflation rates are defined as: $\pi_t^c = \frac{P_t^c}{P_{t-1}^c}$; $\pi_t = \frac{P_t}{P_{t-1}}$ and $\pi_t = \frac{P_t^m}{P_{t-1}^m}$. Note that some price ratios are explicitly defined in order to save on notations. In Dynare, it requires to define a variable for each price ratio.

Financially included and optimising Households

OHs maximise their utility with respect to domestic and foreign bonds holding and consumption. The first order conditions associated to OHs with shadow value υ_t on their budget constraint (3.4.3) are given by:

$$w.r.t.\ C_t^o \quad : \quad (C_t^o)^{-\sigma_c}\left(C_{t-1}^o\right)^{-b(1-\sigma_c)} = \psi_t \frac{P_t^c}{P_t}(1+\tau^c) \tag{3.8.4}$$

$$w.r.t.\ B_{t+1} \quad : \quad \psi_t = \beta \mathrm{E}_t \frac{\psi_{t+1}}{\pi_{t+1}} \varepsilon_{b,t} R_t \tag{3.8.5}$$

$$w.r.t.\ B_{t+1}^* \quad : \quad \psi_t = \beta \mathrm{E}_t \frac{\psi_{t+1}}{\pi_{t+1}} \frac{S_{t+1}}{S_t} \varepsilon_{b,t} R_t^* \Phi(A_t, \tilde{\phi}_t) \tag{3.8.6}$$

where these variables are stationarized following Altig et al. (2003) such that $x_t = \frac{X_t}{P_t}$ for nominal variables while the Lagrange multiplier is redefined as $\psi_t = \upsilon_t P_t$.

OHs also maximise their utility with respect to the capital stock and investment in each sector $q \in (p, f)$ subject to their budget constraint (3.4.3) and capital accumulation rule (3.4.4):

$$w.r.t.\ K_{t+1}^q \quad : \quad \psi_t \frac{P_t^{k,q}}{P_t} = \beta \psi_{t+1} \left((1-\tau^k) r_{t+1}^{k,q} + (1-\delta) \frac{P_{t+1}^{k,q}}{P_{t+1}} \right) \tag{3.8.7}$$

$$\begin{aligned} w.r.t.\ I_t^q \quad : \quad & -\psi_t \frac{P_t^i}{P_t} + \psi_t \frac{P_t^{k,q}}{P_t} \Upsilon_t \left(1 - \tilde{S}\left(\frac{I_t^q}{I_{t-1}^q}\right) - \tilde{S}'\left(\frac{I_t^q}{I_{t-1}^q}\right) \frac{I_t^q}{I_{t-1}^q} \right) \\ + \quad & \beta \mathrm{E}_t \left(\frac{P_{t+1}^{k,q}}{P_{t+1}} \psi_{t+1} \Upsilon_{t+1} \tilde{S}'\left(\frac{I_{t+1}^q}{I_t^q}\right) \left(\frac{I_{t+1}^q}{I_t^q}\right)^2 \right) = 0 \end{aligned} \tag{3.8.8}$$

where $r_t^k \equiv \frac{R_t^k}{P_t}$ is the rental rate of capital corresponding to marginal productivity of capital and $\frac{P_t^{k,q}}{P_t}$ is the real price of the capital good (introduced for convenience).

Country risk premium Combining the First Order Conditions (FOCs) with respect to domestic and foreign bonds gives the uncovered interest rate parity (UIP) condition:

$$R_t = R_t^* \Phi(A_t, \tilde{\phi}_t) \mathrm{E}_t \frac{S_{t+1}}{S_t}$$

This last equality shows that the spread between domestic and foreign nominal risk free rates depends on the anticipated domestic currency depreciation, the country-wide foreign debt and an UIP shock.

Capital Accumulation The capital accumulation rule reads:

$$K_{t+1}^q = (1-\delta) K_t^q + \Upsilon_t (1 - \tilde{S}(I_t / I_{t-1})) I_t \tag{3.8.9}$$

Investment Basket The two investment demand functions are given by maximising the investment basket under a fixed investment spending:

$$I_t^{d,q} = (1-\omega_i)\left[\frac{P_t}{P_t^i}\right]^{-\eta_i} I_t^q, \tag{3.8.10}$$

$$I_t^{m,q} = \omega_i \left[\frac{P_t^m}{P_t^i}\right]^{-\eta_i} I_t^q, \tag{3.8.11}$$

where P_t^i is the aggregate investment price given by:

$$P_t^i = \left[(1-\omega_i)(P_t)^{1-\eta_i} + \omega_i (P_t^m)^{1-\eta_i}\right]^{1/(1-\eta_i)}$$

which is made stationary as follows:

$$\left(\pi_t^i\right)^{1-\eta_i} = (1-\omega_i)\left(\pi_t \frac{P_{t-1}}{P_{t-1}^i}\right)^{1-\eta_i} + \omega_i \left(\pi_t^m \frac{P_{t-1}^m}{P_{t-1}^i}\right)^{1-\eta_i} \tag{3.8.12}$$

where $\pi_t^i = \frac{P_t^i}{P_{t-1}^i}$.

Rule-of-thumb households

ROTHs aggregate stationary budget constraint is given by

$$\int_0^1 (1+\tau^c) P_t^c C_{l,t} \mathrm{d}l = \int_0^1 \left(\frac{1-\tau^y}{1+\tau^w} \overline{W}_{l,t} N_{l,t} + (1-N_{l,t})\varpi\right) \mathrm{d}l \ ,$$

In the EHL version of the model, using labour demand (3.4.21), the definition of aggregate consumption and $\overline{W}_{l,t} N_{l,t} = W_{l,t} H_{l,t}$ imply that

$$(1+\tau^c) P_t^c C_t^R = \left(\frac{1-\tau^y}{1+\tau^w}\right) W_t^{\varepsilon_w} H_t^R \int_0^1 \left(W_{l,t}\right)^{1-\varepsilon_w} \mathrm{d}j \ ,$$

and using the wage index (3.4.22) yields

$$(1+\tau^c)\frac{P_t^c}{P_t} C_t^r = \frac{1-\tau^y}{1+\tau^w} w_t H_t^R \tag{3.8.13}$$

where $w_t = \frac{W_t}{P_t}$.

In the GTT version of the model, ROTHs can be employed in the primary sector, employed in the secondary sector or unemployed. Therefore,

$$(1+\tau^c)\frac{P_t^c}{P_t}C_t^{RP} = \frac{1-\tau^y}{1+\tau^w}\overline{w}_t^p \tag{3.8.14}$$

$$(1+\tau^c)\frac{P_t^c}{P_t}C_t^{RF} = \frac{1-\tau^y}{1+\tau^w}\overline{w}_t^f \tag{3.8.15}$$

$$(1+\tau^c)\frac{P_t^c}{P_t}C_t^{RP} = \varpi_t \tag{3.8.16}$$

and aggregate ROTHs consumption is

$$C_t^R = \frac{1}{2}\left(N_t^p C_t^{RP} + N_t^f C_t^{RF} + U_t C_t^{RU}\right) \tag{3.8.17}$$

3.8.2 Firms

Here is the profit maximisation problem of the firms in the commodity and manufacturing sectors.

Commodity sector

Domestic commodity producers Commodity producers combine capital K_t^p, labour $L_t^p = N_t^p H_t^p$ and land (fixed to 1) to produce a commodity input. In the EHL version of the model $L_t^p = H_t^p$. Cost minimisation gives the capital to hours ratio:

$$\frac{K_t^p}{H_t^p} = \left(\frac{\alpha_p}{1-\alpha_p-\beta_p}\right)\frac{w_t^p}{r_t^{k,p}}, \tag{3.8.18}$$

Since commodity producers operate in a perfectly competitive environment, the marginal (hourly) cost of labour must equalise its productivity:

$$w_t^p = (1-\alpha_p-\beta_p)\frac{Y_t^p}{H_t^p}\frac{S_t P_t^{*p}}{P_t} \tag{3.8.19}$$

In the GTT bargaining framework, hours are set optimally to maximise the global surplus such that the marginal utility of hours worked (the production value in term of consumption utility) must equalise its dis-utility (from labour efforts):

$$(1-\alpha_p-\beta_p)\frac{Y_t^p}{H_t^p}\frac{S_t P_t^{*p}}{P_t}\frac{U'(C_t^o)}{P_t^c/P_t} = U'(H_t^p) \tag{3.8.20}$$

And the FOC for capital is simply:

$$r_t^{k,p} = \alpha_p \frac{Y_t^p}{K_t^p}\frac{S_t P_t^{*p}}{P_t} \tag{3.8.21}$$

Foreign commodity market Foreign demand for commodities comes from their use as inputs in the foreign production process (while supply is exogenous and therefore do not require to compute any FOCs). For simplicity, let us define a labour-capital aggregate:

$$LK_t^* = LK_0^* \left(\frac{\varepsilon_{k,t}^* K_t^*}{K_0^*}\right)^{\alpha^*} \left(\frac{L_t^*}{L_0^*}\right)^{(1-\alpha^*)}, \tag{3.8.22}$$

In particular, foreign firms combine a labour-capital aggregate to the commodity input in a CES function. The FOCs for this cost minimisation problem give:

$$\begin{aligned} P_t^p &= \beta^* \lambda_t^* P_t^* Y_0^* \left[\beta^* \left(\frac{Y_t^{p*}}{Y_0^{p*}}\right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} + (1-\beta^*)\left(\frac{LK_t^*}{LK_0^*}\right)^{\frac{\sigma_p^*-1}{\sigma_p^*}}\right]^{\frac{\sigma_p^*}{\sigma_p^*-1}-1} \left(\frac{Y_t^{p*}}{Y_0^{p*}}\right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} \frac{1}{Y_t^{p*}} \\ \bar{MC}_t^* &= (1-\beta^*)\lambda_t^* P_t^* Y_0^* \left[\beta^* \left(\frac{Y_t^{p*}}{Y_0^{p*}}\right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} + (1-\beta^*)\left(\frac{LK_t^*}{LK_0^*}\right)^{\frac{\sigma_p^*-1}{\sigma_p^*}}\right]^{\frac{\sigma_p^*}{\sigma_p^*-1}-1} \left(\frac{LK_t^*}{LK_0^*}\right)^{\frac{\sigma_p^*-1}{\sigma_p^*}} \frac{1}{LK_t^*} \end{aligned}$$

where P_t^{p*} is the commodity price in foreign currency, $\bar{MC}_t^*$ is the unit marginal cost of the labour-capital aggregate LK_t^* and $\lambda_t^* P_t$ is the nominal unit production cost of the final good Y_t^*. These FOCs give the commodity ratio:

$$\frac{Y_t^{p*}}{LK_t^*} = \left(\frac{\bar{MC}_t^p}{P_t^{p*}} \frac{\beta^*}{1-\beta^*}\right)^{\sigma_p^*} \left(\frac{LK_0^*}{Y_0^{p*}}\right)^{\sigma_p^*-1} \tag{3.8.23}$$

where we can see that commodity demand depends on its price relative to the labour-capital input (where σ_p^* is the elasticity of substitution of commodities) and to the intensity of labour and capital used in the foreign economy. It also gives the final good marginal cost:

$$\lambda_t^* = \frac{1}{P_t^* Y_0^*} \left((\beta^*)^{\sigma_p^*} \left(P_t^{p*} Y_0^{p*}\right)^{1-\sigma_p^*} + (1-\beta^*)^{\sigma_p^*} \left(\bar{MC}_t^* LK_0^*\right)^{1-\sigma_p^*}\right)^{\frac{1}{1-\sigma_p^*}} \tag{3.8.24}$$

Secondary sector

Secondary good producers In the EHL framework, cost minimization problem for the intermediate firm i in period t is given by

$$\min_{K_{i,t}^f, H_{i,t}^f,} W_t^f H_{i,t}^f + R_t^{k,f} K_{i,t}^f + \lambda_t P_t Y_{i,t}^f$$

where the Lagrange multiplier $\lambda_t P_t$ represents the nominal cost of producing one additional unit of the domestic good and λ_t is the real marginal cost.

The FOCs, with respect to $H_{i,t}^f$ and $K_{i,t}^f$, for firm's i cost minimization problem are given by:

$$\begin{aligned} W_t^f &= (1-\alpha)\lambda_t P_t Y_0^f \left(\frac{\varepsilon_{k,t} K_t^f}{K_0^f}\right)^{\alpha_f} \left(\frac{H_t^f}{H_0^f}\right)^{(1-\alpha_f)} \frac{1}{H_t^f} \\ R_t^{k,f} &= \alpha\lambda_t P_t Y_0^f \left(\frac{\varepsilon_{k,t} K_t^f}{K_0^f}\right)^{\alpha_f} \left(\frac{H_t^f}{H_0^f}\right)^{(1-\alpha_f)} \frac{1}{K_t^f} \end{aligned}$$

From those equations we can find the capital to labour ratio:

$$\frac{K_t^f}{H_t^f} = \left(\frac{\alpha_f}{1-\alpha_f}\right) \frac{w_t^f}{r_t^{k,f}}, \tag{3.8.25}$$

As well as the equilibrium real marginal cost of the domestic input mc_t:

$$mc_t \equiv \lambda_t = \frac{1}{Y_0^f} \left(\frac{H_0^f}{1-\alpha_f}\right)^{1-\alpha_f} \left(\frac{K_0^f}{\alpha_f}\right)^{\alpha_f} \left(\frac{r_t^{k,f}}{\varepsilon_{k,t}}\right)^{\alpha_f} \left(w_t^f\right)^{1-\alpha_f} \tag{3.8.26}$$

In the GTT bargaining framework, hours are set optimally to maximise the global surplus such that the marginal utility of hours worked (the production value in term of consumption utility) must equalise its dis-utility (from labour efforts):

$$(1-\alpha_f)\frac{Y_t^f}{H_t^f} mc_t \frac{U'(C_t^o)}{P_t^c/P_t} = U'(H_t^f) \tag{3.8.27}$$

And the FOC for capital is simply:

$$r_t^{k,f} = \alpha_f \frac{Y_t^f}{K_t^f} mc_t \tag{3.8.28}$$

Domestic Distributors The optimization problem faced by the intermediate distributor i when setting its price at time t taking aggregator's demand as given reads:

$$\max_{P_t^{new}} \mathrm{E}_t \sum_{s=0}^{\infty} (\beta\xi_d)^s \upsilon_{t+s} \left(P_{i,t+s} - MC_{t+s}\right) Y_{i,t+s}^d$$

where

$$\begin{aligned}
P_{i,t+s} &= (\pi_t...\pi_{t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}P_t^{new}\\
Y_{i,t+s}^d &= \left(\frac{(\pi_t...\pi_{t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}P_t^{new}}{P_{t+s}}\right)^{-\varepsilon_d} Y_{t+s}^d\\
Y_{t+s}^d &= C_{t+s}^d + I_{t+s}^d
\end{aligned}$$

These expressions can be used to rewrite the maximisation problem as:

$$\mathrm{E}_t\sum_{s=0}^{\infty}(\beta\xi_d)^s\psi_{t+s}\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}p_t^{new}}{\Pi_{t+1,t+s}} - mc_{t+s}\right)\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}p_t^{new}}{\Pi_{t+1,t+s}}\right)^{-\varepsilon_d} Y_{t+s}^d$$

where $p_t^{new} = \frac{P_t^{new}}{P_t}$. Distributing for convenience gives:

$$\mathrm{E}_t\sum_{s=0}^{\infty}(\beta\xi_d)^s\psi_{t+s}\left(\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}p_t^{new}}{\Pi_{t+1,t+s}}\right)^{1-\varepsilon_d} - mc_{t+s}\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}p_t^{new}}{\Pi_{t+1,t+s}}\right)^{-\varepsilon_d}\right) Y_{t+s}^d$$

The FOC with respect to p_t^{new} reads:

$$\begin{aligned}
&(\varepsilon_d - 1)(p_t^{new})^{-\varepsilon_d}\,\mathrm{E}_t\sum_{s=0}^{\infty}(\beta\xi_d)^s\psi_{t+s}\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}}\right)^{1-\varepsilon_d} Y_{t+s}^d\\
&= \varepsilon_d(p_t^{new})^{-\varepsilon_d-1}\,\mathrm{E}_t\sum_{s=0}^{\infty}(\beta\xi_d)^s\psi_{t+s}\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}}\right)^{-\varepsilon_d} mc_{t+s}Y_{t+s}^d
\end{aligned}$$

and can be rewritten as:

$$p_t^{new} = \frac{\varepsilon_d}{\varepsilon_d - 1}\frac{\mathrm{E}_t\sum_{s=0}^{\infty}(\beta\xi_d)^s\psi_{t+s}\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}}\right)^{-\varepsilon_d} mc_{t+s}Y_{t+s}^d}{\mathrm{E}_t\sum_{s=0}^{\infty}(\beta\xi_d)^s\psi_{t+s}\left(\frac{(\Pi_{t,t+s-1})^{\kappa_d}(\bar{\pi})^{(1-\kappa_d)s}}{\Pi_{t+1,t+s}}\right)^{1-\varepsilon_d} Y_{t+s}^d}$$

which can also be rewritten as a set of three equations:

$$p_t^{new} = \frac{\varepsilon_d}{\varepsilon_d - 1}\frac{X_{1,t}^D}{X_{2,t}^D} \tag{3.8.29}$$

$$X_{1,t}^D = \psi_t mc_t(C_t^d + I_t^d) + \beta\xi_d\left(\frac{\pi_t^{\kappa_d}\bar{\pi}^{1-\kappa_d}}{\pi_{t+1}}\right)^{-\varepsilon_d}\mathrm{E}_t X_{1,t+1}^D \tag{3.8.30}$$

$$X_{2,t}^D = \psi_t(C_t^d + I_t^d) + \beta\xi_d\left(\frac{\pi_t^{\kappa_d}\bar{\pi}^{1-\kappa_d}}{\pi_{t+1}}\right)^{1-\varepsilon_d}\mathrm{E}_t X_{2,t+1}^D \tag{3.8.31}$$

In addition, the domestic price index evolves according to:

$$1 = \xi_d \left(\frac{\pi_{t-1}^{\kappa_d} \bar{\pi}^{1-\kappa_d}}{\pi_t} \right)^{1-\varepsilon_d} + (1-\xi_d) \left(p_t^{new}\right)^{1-\varepsilon_d} \tag{3.8.32}$$

Finally, the price dispersion measure

$$\upsilon_t^d = \int_0^1 \left(\frac{P_{i,t}}{P_t} \right)^{-\varepsilon_d} di$$

can be written as:

$$\upsilon_t^d = (1-\xi_d) \left(\frac{P_t^{new}}{P_t} \right)^{-\varepsilon_d} + \int_{1-\xi_d}^1 \left(\frac{(\pi_{t-1})^{\kappa_d} (\bar{\pi})^{1-\kappa_d} P_{i,t-1}}{P_t} \right)^{-\varepsilon_d} di$$

which simplifies to:

$$\upsilon_t^d = (1-\xi_d) \left(p_t^{new}\right)^{-\varepsilon_d} + \int_{1-\xi_d}^1 \left(\frac{(\pi_{t-1})^{\kappa_d} (\bar{\pi})^{1-\kappa_d} p_{i,t-1}}{\pi_t} \right)^{-\varepsilon_d} di$$

then to:

$$\upsilon_t^d = (1-\xi_d) \left(p_t^{new}\right)^{-\varepsilon_d} + \xi_d \left(\frac{(\pi_{t-1})^{\kappa_d} (\bar{\pi})^{1-\kappa_d}}{\pi_t} \right)^{-\varepsilon_d} \upsilon_{t-1}^d \tag{3.8.33}$$

which is a function of aggregate variables only.

Importing and exporting distributors Optimisation in the importing and exporting distributors price setting problem is similar to the domestic good price setting problem presented above. The difference is that importing and exporting firms face the following marginal cost to sale price ratio: $\frac{S_t MC_t^*}{P_t^m}$ and $\frac{MC_t}{S_t P_t^x}$, respectively. The difference with Adolfson et al. (2007) is that the importing firm consider MC_t^* instead of P_t^* for its nominal marginal cost, and that exporting firms consider MC_t instead of P_t.

3.8.3 Labour market

This subsection describes the FOC for the labour market in the EHL and GTT frameworks.

Monopolistic competition and staggered wage contracts

Wage setting Each household has a probability $(1-\xi_w)$ to be allowed to optimally reset the nominal wage. Otherwise, wage is indexed on previous period consumer price inflation π_{t-1}^c

and the Central Bank inflation target $\bar{\pi}$. Households that can re optimize their wage maximize

$$\sum_{s=0}^{\infty}(\beta\xi_w)^s\left(\upsilon_{t+s}\frac{1-\tau^y}{1+\tau^w}W_{j,t+s}h_{j,t+s}-A_h\frac{(h_{j,t+s})^{1+\sigma_h}}{1+\sigma_h}\right)$$

where

$$\begin{aligned}
W_{j,t+s} &= W_{j,t}^{new}\left(\pi_t^c...\pi_{t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}\\
h_{j,t+s} &= \left(\frac{W_{j,t+s}}{W_{t+s}}\right)^{-\varepsilon_w}H_{t+s}^o\\
&= \left(\frac{W_{j,t}^{new}\left(\pi_t^c...\pi_{t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}}{W_{t+s}}\right)^{-\varepsilon_w}H_{t+s}^o
\end{aligned}$$

with respect to the new wage W_t^{new}. Note that υ_{t+s} is the Lagrange multiplier in the household optimisation problem and that it is also useful to define

$$\begin{aligned}
\Pi_{t,t+s-1}^c &= \left(\pi_t^c...\pi_{t+s-1}^c\right)\\
\Pi_{t+1,t+s} &= \left(\pi_{t+1}...\pi_{t+s}\right)
\end{aligned}$$

Rearranging using the above equations gives:

$$\sum_{s=0}^{\infty}(\beta\xi_w)^s\left(\upsilon_{t+s}\frac{1-\tau^y}{1+\tau^w}W_{j,t}^{new}\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}\left(\frac{W_{j,t}^{new}\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}}{W_{t+s}}\right)^{-\varepsilon_w}H_{t+s}^o\right.$$
$$\left.-\frac{A_h}{1+\sigma_h}\left(\frac{W_{j,t}^{new}\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}}{W_{t+s}}\right)^{-(1+\sigma_h)\varepsilon_w}\left(H_{t+s}^o\right)^{1+\sigma_h}\right)$$

Expressing it in term of real wage and simplifying gives:

$$\sum_{s=0}^{\infty}(\beta\xi_w)^s\left(\psi_{t+s}\frac{1-\tau^y}{1+\tau^w}\left(\frac{w_{j,t}^{new}\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}}{\Pi_{t+1,t+s}}\right)^{1-\varepsilon_w}\left(w_{t+s}\right)^{\varepsilon_w}H_{t+s}^o\right.$$
$$\left.-\frac{A_h}{1+\sigma_h}\left(\frac{w_{j,t}^{new}\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}}{w_{t+s}\Pi_{t+1,t+s}}\right)^{-(1+\sigma_h)\varepsilon_w}\left(H_{t+s}^o\right)^{1+\sigma_h}\right)$$

The FOC is now easy to derive and reads:

$$(\varepsilon_w - 1)\left(w_{j,t}^{new}\right)^{-\varepsilon_w} \sum_{s=0}^{\infty} (\beta\xi_w)^s \psi_{t+s} \frac{1-\tau^y}{1+\tau^w} \left(\frac{\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w} \bar{\pi}^{(1-\kappa_w)s}}{\Pi_{t+1,t+s}} \right)^{1-\varepsilon_w} (w_{t+s})^{\varepsilon_w} H_{t+s}^o$$

$$= \varepsilon_w \left(w_{j,t}^{new}\right)^{-(1+\sigma_h)\varepsilon_w - 1} \sum_{s=0}^{\infty} (\beta\xi_w)^s A_h \left(\frac{\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w} \bar{\pi}^{(1-\kappa_w)s}}{w_{t+s}\Pi_{t+1,t+s}} \right)^{-(1+\sigma_h)\varepsilon_w} \left(H_{t+s}^o\right)^{1+\sigma_h}$$

which simplifies to:

$$\left(w_t^{new}\right)^{1+\sigma_h\varepsilon_w} = \frac{\varepsilon_w}{\varepsilon_w - 1} \frac{\sum_{s=0}^{\infty} (\beta\xi_w)^s A_h \left(\frac{\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w} \bar{\pi}^{(1-\kappa_w)s}}{w_{t+s}\Pi_{t+1,t+s}} \right)^{-(1+\sigma_h)\varepsilon_w} \left(H_{t+s}^o\right)^{1+\sigma_h}}{\sum_{s=0}^{\infty} (\beta\xi_w)^s \psi_{t+s} \frac{1-\tau^y}{1+\tau^w} \left(\frac{\left(\Pi_{t,t+s-1}^c\right)^{\kappa_w} \bar{\pi}^{(1-\kappa_w)s}}{\Pi_{t+1,t+s}} \right)^{1-\varepsilon_w} (w_{t+s})^{\varepsilon_w} H_{t+s}^o}$$

since all re-optimising households set the same wage. This last equation is the wage-Phillips curve with partial indexation. In Dynare, the infinite sum can be rewritten as a set of three equations:

$$\left(w_t^{new}\right)^{1+\sigma_h\varepsilon_w} = \left(\frac{\varepsilon_w}{\varepsilon_w - 1}\right) \frac{X_{1,t}^H}{X_{2,t}^H} \tag{3.8.34}$$

$$X_{1,t}^H = A_h w_t^{(1+\sigma_h)\varepsilon_w} \left(H_t^o\right)^{1+\sigma_h} + \beta\xi_w \left(\frac{\left(\pi_t^c\right)^{\kappa_w} \bar{\pi}^{(1-\kappa_w)}}{\pi_{t+1}} \right)^{-(1+\sigma_h)\varepsilon_w} \mathrm{E}_t X_{1,t+1}^H \tag{3.8.35}$$

$$X_{2,t}^H = \frac{1-\tau^y}{1+\tau^w} \psi_t w_t^{\varepsilon_w} H_t^o + \beta\xi_w \left(\frac{\left(\pi_t^c\right)^{\kappa_w} \bar{\pi}^{(1-\kappa_w)}}{\pi_{t+1}} \right)^{-(\varepsilon_w - 1)} \mathrm{E}_t X_{2,t+1}^H \tag{3.8.36}$$

Labour packer The real wage index evolves according to

$$w_t^{1-\varepsilon_w} = (1-\xi_w)\left(w_t^{new}\right)^{1-\varepsilon_w} + \xi_w \left(\frac{\left(\pi_{t-1}^c\right)^{\kappa_w} \bar{\pi}^{1-\kappa_w} w_{t-1}}{\pi_t} \right)^{1-\varepsilon_w} \tag{3.8.37}$$

Labour dispatcher The labour allocation problem gives primary and secondary sectors wages function of the relative demand for labour in each sectors:

$$w_t^f = \left[\frac{H_t^f}{(1-\omega_h)H_t} \right]^{1/\eta_h} w_t, \tag{3.8.38}$$

$$w_t^p = \left[\frac{H_t^p}{\omega_h H_t} \right]^{1/\eta_h} w_t, \tag{3.8.39}$$

where $w_t^p = \frac{W_t^p}{P_t}$ and $w_t^f = \frac{W_t^f}{P_t}$

Search and matching with staggered wage bargaining

This subsection presents the FOCs for the primary sector. The final good sector is similar.

Households employment surplus In stationary form, the aggregate employees surplus reads:

$$S_t^{w,p} = \overline{w}_t^p - \varpi - \left[\frac{U(H_t^p)}{\upsilon_t} + \beta\frac{\psi_{t+1}}{\psi_t}\left(p_t^p S_{t+1}^{w,p} + p_t^f S_{t+1}^{w,f}\right)\right] + (1-\delta_n)\beta\frac{\psi_{t+1}}{\psi_t}S_{t+1}^{w,p} \quad (3.8.40)$$

Let us define the minimum wage level acceptable in the flexible wage environment as:

$$\overline{w}_t^{min,p} = \varpi_t + \left[\frac{U(H_t^p)}{\upsilon_t} + \beta\frac{\psi_{t+1}}{\psi_t}\left(p_t^p S_{t+1}^{w,p} + p_t^f S_{t+1}^{w,f}\right)\right] \quad (3.8.41)$$

Firms employment surplus In stationary form, the aggregate employers surplus is:

$$S_t^{f,p} = \frac{P_t^p}{P_t}(1-\alpha_p-\beta_p)\frac{Y_t}{N_t^p} - \overline{w}_t^p + \frac{\chi\theta}{1+\theta}\left(\frac{V_t^p}{N_t^p}\right)^{1+\theta} + (1-\delta_n)\beta\frac{\psi_{t+1}}{\psi_t}S_{t+1}^{f,p} \quad (3.8.42)$$

Let us define the maximum wage level acceptable in the flexible wage environment as:

$$\overline{w}_t^{max,p} = \frac{P_t^p}{P_t}(1-\alpha_p-\beta_p)\frac{Y_t}{N_t^p} + \frac{\chi\theta}{1+\theta}\left(\frac{V_t^p}{N_t^p}\right)^{1+\theta} \quad (3.8.43)$$

Wage bargaining Bargaining is modelled following Thomas (2008). Unions and firms agree to share the surplus. They set the wage such that workers receive an expected share ω_w of the total surplus $S_t^{w,p} + S_t^{f,p}$ over the contract duration. At every period, there is a targeted wage $\overline{w}_t^{tar,p}$ that would satisfy the surplus sharing rule:

$$\overline{w}_t^{tar,p} = \omega_w\overline{w}_t^{max,p} + (1-\omega)\overline{w}_t^{min,p} \quad (3.8.44)$$

Since each contract has a probability δ_n to stop at every period, and since each worker has a probability $1-\xi_w$ to renegotiate, the optimal wage has to satisfy

$$\mathrm{E}_0^i\sum_{s=0}^{\infty}(\beta\xi_w)^s(1-\delta_n)^s\frac{\psi_{t+s}}{\psi_t}\left(\overline{w}_t^{new}\left(\frac{\left(\pi_t^c\ldots\pi_{t+s-1}^c\right)^{\kappa_w}\bar{\pi}^{(1-\kappa_w)s}}{(\pi_{t+1}\ldots\pi_{t+s})}\right) - \overline{w}_{t+s}^{tar,p}\right).$$

This equation can be written as a set of three equations to avoid the infinite sum:

$$\overline{w}_t^{new,p} = \frac{Z_{1,t}}{Z_{2,t}} \quad (3.8.45)$$

$$Z_{1,t} = \psi_t\overline{w}_t^{tar,p} + \beta\xi_w(1-\delta_n)Z_{1,t+1} \quad (3.8.46)$$

$$Z_{2,t} = \psi_t + \beta\xi_w(1-\delta_n)\left(\frac{(\pi_t^c)^{\kappa_w}\,\bar{\pi}^{(1-\kappa_w)}}{\pi_{t+1}}\right)Z_{2,t+1} \tag{3.8.47}$$

Hours decision Hours decisions are reported in the firms section.

Employment decision Firms in the primary sector maximise their profits w.r.t. vacancies. The FOC is:

$$\frac{\chi\left(\frac{V_t^p}{N_t^p}\right)^{\theta}}{q_t^p} = \beta\frac{\psi_{t+1}}{\psi_t}\left[\frac{P_{t+1}^p}{P_{t+1}}(1-\alpha_p-\beta_p)\frac{Y_{t+1}^p}{N_{t+1}^p} - \overline{w}_{t+1}^p + \frac{\chi\theta\left(\frac{V_{j,t}^p}{N_{j,t}^p}\right)^{1+\theta}}{1+\theta} + (1-\delta_n)\frac{\chi\left(\frac{V_{t+1}^p}{N_{t+1}^p}\right)^{\theta}}{q_{t+1}^p}\right]$$

3.8.4 Aggregate Welfare

OHs aggregate utility In the EHL version of the model, recall that the aggregate utility level for OHs is given by

$$U_t^S = \frac{\left(C_t^o/(C_{t-1}^o)^b\right)^{1-\sigma_c}-1}{1-\sigma_c} - \frac{A_h(H_t^o)^{1+\sigma_h}}{1+\sigma_h}\upsilon_t^h \tag{3.8.48}$$

where

$$\upsilon_t^h = \int_0^1\left(\frac{W_{j,t}}{W_t}\right)^{-\varepsilon_w(1+\sigma_l)}dj$$

The latter term can be re-expressed as a function of aggregate variables only. By the Calvo assumption, it implies that

$$\upsilon_t^h = (1-\xi_w)\left(\frac{W_t^{new}}{W_t}\right)^{-\varepsilon_w(1+\sigma_l)} + \int_{1-\xi_w}^1\left(\frac{\left(\pi_{t-1}^c\right)^{\kappa_w}(\bar{\pi})^{1-\kappa_w}W_{j,t-1}}{W_t}\right)^{-\varepsilon_w(1+\sigma_l)}dj$$

Rewriting this expression gives:

$$\upsilon_t^h = (1-\xi_w)\left(\frac{w_t^{new}}{w_t}\right)^{-\varepsilon_w(1+\sigma_l)} + \int_{1-\xi_w}^1\left(\frac{w_{t-1}\left(\pi_{t-1}^c\right)^{\kappa_w}(\bar{\pi})^{1-\kappa_w}W_{j,t-1}}{w_t\pi_tW_{t-1}}\right)^{-\varepsilon_w(1+\sigma_l)}dj$$

which simplifies to:

$$\upsilon_t^h = (1-\xi_w)\left(\frac{w_t^{new}}{w_t}\right)^{-\varepsilon_w(1+\sigma_l)} + \left(\frac{w_{t-1}\left(\pi_{t-1}^c\right)^{\kappa_w}(\bar{\pi})^{1-\kappa_w}}{w_t\pi_t}\right)^{-\varepsilon_w(1+\sigma_l)}\int_{1-\xi_w}^1\left(\frac{W_{j,t-1}}{W_{t-1}}\right)^{-\varepsilon_w(1+\sigma_l)}dj$$

and then to:

$$\upsilon_t^h = (1-\xi_w)\left(\frac{w_t^{new}}{w_t}\right)^{-\varepsilon_w(1+\sigma_l)} + \xi_w\left(\frac{w_{t-1}\left(\pi_{t-1}^c\right)^{\kappa_w}(\bar{\pi})^{1-\kappa_w}}{w_t\pi_t}\right)^{-\varepsilon_w(1+\sigma_l)} \upsilon_{t-1}^h \quad (3.8.49)$$

which is indeed a function of aggregate variables only and can be introduced in the model. In the GTT version of the model, no extra computations are needed.

Rule of thumb's aggregate utility In the EHL model, recall that their aggregate level of utility is given by

$$U_t^R = \frac{\left(C_t^R/(C_{t-1}^R)^b\right)^{1-\sigma_c}\upsilon_t^c - 1}{1-\sigma_c} - \frac{A_{h,r}(H_t^R)^{1+\sigma_h}}{1+\sigma_h}\upsilon_t^h \quad (3.8.50)$$

where

$$\upsilon_t^c = \int_0^1 \left(\frac{W_{j,t}}{W_t}\right)^{(1-\varepsilon_w)(1-\sigma_c)} dj$$

This latter term can also be written as a function a aggregate variables only using a similar procedure as above:

$$\upsilon_t^c = (1-\xi_w)\left(\frac{w_t^{new}}{w_t}\right)^{(1-\varepsilon_w)(1-\sigma_c)} + \xi_w\left(\frac{w_{t-1}\left(\pi_{t-1}^c\right)^{\kappa_w}(\bar{\pi})^{1-\kappa_w}}{w_t\pi_t}\right)^{(1-\varepsilon_w)(1-\sigma_c)} \upsilon_{t-1}^c \quad (3.8.51)$$

In the GTT framework, recall that

$$\begin{aligned} U_t^R &= \frac{1}{2}\left(N_t^p\frac{\left(C_t^{RP}/(C_{t-1}^R)^b\right)^{1-\sigma_c}\upsilon_t^{cp}-1}{1-\sigma_c} + N_t^f\frac{\left(C_t^{RF}/(C_{t-1}^R)^b\right)^{1-\sigma_c}\upsilon_t^{cf}-1}{1-\sigma_c}\right) \quad (3.8.52)\\ &+ \frac{1}{2}\left(U_t\frac{\left(C_t^{RU}/(C_{t-1}^R)^b\right)^{1-\sigma_c}-1}{1-\sigma_c} - \frac{A_hN_t^p(H_t^p)^{1+\sigma_h}}{1+\sigma_h} - \frac{A_hN_t^f(H_t^f)^{1+\sigma_h}}{1+\sigma_h}\right)\end{aligned}$$

where, using again the same procedure:

$$\upsilon_t^{cp} = (1-\xi_w)\left(\frac{\bar{w}_t^{p*}}{\bar{w}_t^p}\right)^{(1-\varepsilon_w)(1-\sigma_c)} + \xi_w\left(\frac{\bar{w}_{t-1}^p\left(\pi_{t-1}^c\right)^{\kappa_w}(\bar{\pi})^{1-\kappa_w}}{\bar{w}_t^p\pi_t}\right)^{(1-\varepsilon_w)(1-\sigma_c)} \upsilon_{t-1}^{cp} \quad (3.8.53)$$

$$\upsilon_t^{cf} = (1-\xi_w)\left(\frac{\bar{w}_t^{f*}}{\bar{w}_t^f}\right)^{(1-\varepsilon_w)(1-\sigma_c)} + \xi_w\left(\frac{\bar{w}_{t-1}^f\left(\pi_{t-1}^c\right)^{\kappa_w}(\bar{\pi})^{1-\kappa_w}}{\bar{w}_t^f\pi_t}\right)^{(1-\varepsilon_w)(1-\sigma_c)} \upsilon_{t-1}^{cf} \quad (3.8.54)$$

3.9 Appendix: Steady state

Here are the details on the computation of steady-state for the domestic economy.

Calibration and choice of units First some variables are calibrated to some values reflecting some freedom in the choice of units:

$$\begin{aligned} Y^f &= Y_0^f = 1 \\ P_0 &= P_0^* = 1 \\ h^r &= h^o = 1/3 \end{aligned}$$

where Y_0^f and P_0 are free choice of units and $h_j = 1/3$ ensures that agents devote on average 1/3 of their time to labour activities and just imposes to calibrate A_h accordingly.

In the EHL version of the model, it implies that total hours worked by OHs and ROTHs is given by $H^r = H^o = 1/3$; that $H = H^r + H^o$ and that the time they spend working in each sectors is given by $H^p = \omega_h H$ and $H^f = (1-\omega_h)H$.

In the GTT version, there is a fraction $U = U^*$ of agents that are unemployed. Others work in the primary sector: $N^p = \omega_h(2-U)$ or in the secondary sector: $N^f = (1-\omega_h)(2-U)$. At steady-state, $H^p = H^f = 1/3$ and $L^p = N^p H^p$ and $L^f = N^f H^f$.

The primary commodity sector's share in GDP is calibrated to ω_p to match its empirical counterpart. it implies that

$$\begin{aligned} Y &= \frac{Y^f}{1-\omega_p} \\ Y^p &= Y_0^p = \omega_p Y \end{aligned}$$

Assuming that inflation and and the risk-free rates are the same in the domestic and foreign economies:

$$\begin{aligned} \pi &= \pi^* \\ R &= R^* \end{aligned}$$

where π and R are calibrated to match the empirical mean of domestic variables. It implies that $dS = 1$ (through the UIP condition). Therefore, all inflations rates are equal to π. By carefully calibrating mark-ups[43] for each distributors, all relative prices γ equalise to one at steady-state.

[43]by assuming that mark-ups in the import and foreign distribution sectors are identical; and that mark-ups in the export and domestic distribution sectors are identical

Households Turning to patient households FOCs, the assumptions presented above imply that:

$$\beta = \frac{\pi}{R}$$

and pin down the real price of capital and its rental rate to

$$\begin{aligned} p_{k'} &= \frac{P^k}{P} = \frac{P^i}{P} = 1 \\ r^k &= \frac{p_{k'}(1-(1-\delta)\beta)}{(1-\tau^k)\beta} \end{aligned}$$

where the real price of capital and its rental rate are the same in both sectors at steady-state.

Final good sector Turning to final good distributors, the marginal costs are given by:

$$\begin{aligned} mc &= mc^x = \frac{\varepsilon_d - 1}{\varepsilon_d} \\ mc^m &= mc^* = \frac{\varepsilon_* - 1}{\varepsilon_*} \end{aligned}$$

In addition, the use of a normalised production function in the final good sector allows to write

$$MC_t Y_t^f = R_t^{k,f} K_t^f + \overline{W}_t^f N_t^f$$

where the capital income share at steady-state is given (in their stationary form) by

$$r^{k,f} K^f = \alpha mc Y^f$$

which implies that

$$K^f = \frac{\alpha Y^f mc}{r^k}$$

It also implies that the value of investment is:

$$I^f = \delta K^f$$

Primary good sector Using once again a Normalised production function implies that

$$S_t P_t^{*p} Y_t^p = R_t^{k,p} K_t^p + \overline{W}_t^p N_t^p + landshare_t$$

where R_t^L is the rental rate of the land input. It implies that

$$r^{k,p}K^p = \alpha_p Y^p$$

which implies

$$K^p = \frac{\alpha_p Y^p}{r^k}$$

Therefore,

$$I^p = \delta K^p$$

Aggregate resource constraints Total, imported and domestic investments are given by

$$\begin{aligned} I &= I^f + I^p \\ I^m &= \omega_i I \\ I^d &= (1-\omega_i)I \end{aligned}$$

The aggregate resource constraint evaluated at steady state reads

$$Y^f - G = C^d + I^d + X^f$$

Plugging steady state domestic consumption values from households yields

$$Y^f - G = (1-\omega_c)C + I^d + X^f$$

The net foreign assets accumulation rule gives

$$C^m + I^m = Y^p + X^f + \left(\frac{R}{\pi} - 1\right)A$$

Plugging steady state value of imported consumption we have,

$$\omega_c C + I^m = Y^p + X^f + \left(\frac{R}{\pi} - 1\right)A$$

Assuming the net foreign asset position[44] is calibrated, there are two equations with only x^f and c unknown. Solving yields

$$\begin{aligned} C &= Y^f - (I^m + I^d + G) + Y^p + \left(\frac{R}{\pi} - 1\right) A \\ X^f &= Y^f - G - C^d - I^d \end{aligned}$$

It implies that $C^m = \omega_c C$ and $C^d = (1-\omega_c)C$.

Wages in EHL version Using once again a Normalised production function and remembering that $\overline{W}_t^f N_t^f = W_t^f H_t^f$ imply that

$$w^f H^f = (1-\alpha) mc Y^f$$

which implies that

$$w^f = \frac{(1-\alpha) Y^f mc}{H^f}$$

Since wages are equal in both sectors at steady-state, $w = w^p = w^f$. In addition, using once again a Normalised production function and remembering that $\overline{W}_t^p N_t^p = W_t^p H_t^p$ imply that

$$w^p H^p = (1 - \alpha_p - \beta_p) Y^p$$

which, since H^p is calibrated and $w^p = w^f$, imposes to set

$$\beta_p = 1 - \alpha_p - \frac{w^p H^p}{Y^p}$$

where $\frac{w^p H^p}{Y^p}$ is the labour income share in the primary sector.

Beveridge curve in GTT version The law of motion of employment implies that

$$\delta_n N^p = q^p V^p$$
$$\delta_n N^p = p^p U$$

[44] Any net foreign asset position can be made consistent with steady state by setting the parameter $\bar{A} = A$ in $\Phi(.)$.

Since employment in each sectors N^p, N^f, the unemployment rate U and the vacancy rate $\frac{V^p}{N^p}$ are set to attain steady-state targets

$$q^p = \frac{\delta_n N^p}{V^p}$$
$$p^p = \frac{\delta_n N^p}{U}$$

Wages in GTT version In the GTT version, it is a bit more complicated to pin down wages (note that the value for capital is the same than in the EHL version since the marginal productivity of capital is equal to its rental rate). The maximum wage value are given by

$$\overline{w}^{max,f} = mc(1-\alpha_f)\frac{Y^f}{N^f} + \frac{\chi\theta}{1+\theta}\left(\frac{V^f}{N^f}\right)^{1+\theta}$$
$$\overline{w}^{max,p} = (1-\alpha_p-\beta_p)\frac{Y^p}{N^p} + \frac{\chi\theta}{1+\theta}\left(\frac{V^p}{N^p}\right)^{1+\theta}$$

where $\beta_p = 1-\alpha_p - \frac{mc(1-\alpha_f)Y^f}{Y^p}\frac{L^p}{L^f}$ such that $\overline{w}^{max,f} = \overline{w}^{max,p}$. It is then possible to use the firm employment decision to get:

$$\overline{w}^f = \overline{w}^{max,f} - \left(\frac{1}{\beta}-(1-\delta_n)\right)\frac{\chi}{\delta_n}\left(\frac{V^p}{N^p}\right)^{1+\theta}$$

and therefore $\overline{w}^{tar,f} = \overline{new,w}^f = \overline{w}^f$.

Disaggregated consumption The consumption of rule of thumbs households is given by $C^R = \frac{1-\tau_y}{(1+\tau_w)(1+\tau_c)}wH^r$ in the EHL model and $C^R = \frac{1-\tau_y}{2(1+\tau_w)(1+\tau_c)}\left(\bar{w}^p N^p + \bar{w}^f N^f + U\varpi\right)$ in the GTT model. The consumption level of OHs is then simply given by $C^o = C - C^r$.

Back to wages in GTT version With C^o, it is possible to compute υ and then the minimum wage value (as a function of ϖ) and the employment surplus with:

$$\begin{aligned}\overline{w}^{min,f} &= \varpi + \left[\frac{U(H^f)}{\upsilon} + \beta\left(p^p S^{w,p} + p^f S^{w,f}\right)\right]\\ S^{w,p} &= \frac{\overline{w}^f - \overline{w}^{min,f}}{1-(1-\delta_n)\beta}\end{aligned}$$

where $S^{w,p} = S^{w,f}$. It implies that the employees surplus share is $\omega_w = \frac{\overline{w}^{max,f} - \overline{w}^f}{\overline{w}^{max,f} - \overline{w}^{min,f}}$ and can be adjusted by calibrating ϖ or χ.

3.10 Appendix: Welfare cost measures

Conditional compensation measures are defined as the fraction of consumption that an agent j would be ready to give up in the economy l in order to be equally well off in that economy than in an alternative economy v, when both economies state variables are initially identical. This appendix shows how to compute conditional compensation for a domestic rule of thumbs household in the EHL environment. The method to derive this measure for OHs, ROTHs and foreign households in the EHL and GTT frameworks is similar.

In order to clarify notations, let $W\left((1-\lambda)\mathbf{C}_j^{R,l},\mathbf{h}_j^{R,l}\right)$ denotes welfare of a rule-of-thumb household j in economy l where this household renounces to a fraction λ of its consumption flow $\mathbf{C}_j^{R,l}$ at every period. Similarly, let $W\left(\mathbf{C}_j^{R,v},\mathbf{h}_j^{R,v}\right)$ be its welfare in economy v.

The maximum fraction λ_u^R of consumption that household j would be ready to give up in economy l in order to be as well off as under economy v should satisfy

$$\mathrm{E}_0 W\left((1-\lambda_u^R)\mathbf{C}_j^{R,l},\mathbf{h}_j^{R,l}\right)=\mathrm{E}_0 W\left(\mathbf{C}_j^{R,v},\mathbf{h}_j^{R,v}\right) \tag{3.10.1}$$

in order to make this household indifferent between the two environments. In this expression, the conditional expectation operator E_0 conditions on the initial state of the economy (assumed to be its steady-state) and integrates over the probability density of aggregate disturbances (business cycle shocks presented in Table 3.1) and idiosyncratic shocks (Calvo price and wage stickiness affecting each households differently). It is therefore convenient to rewrite this expression as

$$\mathrm{E}_0\int_0^1 W\left((1-\lambda_u^R)\mathbf{C}_j^{R,l},\mathbf{h}_j^{R,l}\right)\mathrm{d}j=\mathrm{E}_0\int_0^1 W\left(\mathbf{C}_j^{R,v},\mathbf{h}_j^{R,v}\right)\mathrm{d}j \tag{3.10.2}$$

where the conditional expectation operator E_0 still conditions on the initial state of the economy but now only integrates over the probability density of aggregate disturbances while the integral explicitly integrates over households idiosyncratic shocks.

Expanding on the left-hand side of the above equation yields

$$\mathrm{E}_0\int_0^1\sum_{t=0}^{\infty}\beta^t\left\{\frac{\left((1-\lambda_u^R)C_{j,t}^{R,l}/\left(C_{t-1}^{R,l}\right)^b\right)^{1-\sigma_c}-1}{1-\sigma_c}-\frac{A_h(h_{j,t}^{R,l})^{1+\sigma_h}}{1+\sigma_h}\right\}\mathrm{d}j=\mathrm{E}_0\int_0^1 W\left(\mathbf{C}_j^{R,v},\mathbf{h}_j^{R,v}\right)\mathrm{d}j \tag{3.10.3}$$

Solving for the integrals in the left and right-hand sides gives

$$\mathrm{E}_0\sum_{t=0}^{\infty}\beta^t\left\{\frac{\left((1-\lambda_u^R)C_t^{R,l}/\left(C_{t-1}^{R,l}\right)^b\right)^{1-\sigma_c}\upsilon_t^c-1}{1-\sigma_c}-\frac{A_h(h_t^{R,l})^{1+\sigma_h}}{1+\sigma_h}\upsilon_t^w\right\}=\mathrm{E}_0 W\left(\mathbf{C}^{R,v},\mathbf{h}^{R,v}\right) \tag{3.10.4}$$

This expression can be solve for λ_u^R. Indeed, rearranging the terms gives

$$\lambda_u^R = 1 - \left(\frac{\mathrm{E}_0 W\left(\mathbf{C}^{R,v}, \mathbf{h}^{R,v}\right) - \mathrm{E}_0 W\left(\mathbf{h}^{R,l}\right) + \frac{1}{(1-\beta)(1-\sigma_c)}}{\mathrm{E}_0 W\left(\mathbf{C}^{R,l}\right) + \frac{1}{(1-\beta)(1-\sigma_c)}} \right)^{\frac{1}{(1-\sigma_c)}} \tag{3.10.5}$$

which can be used in order to measure welfare costs. This expression for λ_u^R can be evaluated provided that we can evaluate the functions $\mathrm{E}_0 W(.)$. These functions are given by

$$\mathrm{E}_0 W\left(\mathbf{C}^{R,v}, \mathbf{h}^{R,v}\right) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(C_t^{R,v}/(C_{t-1}^{R,v})^b\right)^{1-\sigma_c} \upsilon_t^c - 1}{1-\sigma_c} - \frac{A_h (h_t^{R,v})^{1+\sigma_h}}{1+\sigma_h} \upsilon_t^w \right\} \tag{3.10.6}$$

$$\mathrm{E}_0 W\left(\mathbf{h}^{R,l}\right) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ -\frac{A_h (h_t^{R,l})^{1+\sigma_h}}{1+\sigma_h} \upsilon_t^w \right\} \tag{3.10.7}$$

$$\mathrm{E}_0 W\left(\mathbf{C}^{R,l}\right) = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(C_t^{R,l}/(C_{t-1}^{R,l})^b\right)^{1-\sigma_c} \upsilon_t^c - 1}{1-\sigma_c} \right\} \tag{3.10.8}$$

and can be evaluated by simulations. It requires to condition the initial state of the economy to be its steady-state, to generate shocks from their probability density and to simulate the model.

In Dynare, the trick is simply to rewrite these sums as

$$W_{t=0}(.) = U_{t=0}(.) + \beta \mathrm{E}_{t=0} W_{t=1}(.) \tag{3.10.9}$$

where $\mathrm{E}_{t=0}$ is the expectation operator conditional on information available at time $t = 0$; and to simulate the model in order to recover the values of $W_{t=0}(.)$. By averaging over enough simulations (and therefore averaging over different realisations of the shocks) the law of large number ensures convergence to $\mathrm{E}_0 W_{t=0}(.)$.

Bibliography

Abel, A. B. (1990). Asset Prices under Habit Formation and Catching Up with the Joneses. *American Economic Review 80*(2), 38–42.

Abradu-Otoo, P., B. Amoah, and M. Bawumia (2003). An investigation of the transmission mechanisms of monetary policy in ghana: A structural vector error correction analysis. Working Papers 2003/02, Bank of Ghana.

Adam, C., S. O'Connell, E. Buffie, and C. Pattillo (2009). Monetary Policy Rules for Managing Aid Surges in Africa. *Review of Development Economics 13*(s1), 464–490.

Adolfson, M., S. Laseen, J. Linde, and M. Villani (2007). Bayesian estimation of an open economy dsge model with incomplete pass-through. *Journal of International Economics 72*(2), 481–511.

Agenor, P.-R., C. J. McDermott, and E. S. Prasad (2000). Macroeconomic Fluctuations in Developing Countries: Some Stylized Facts. *World Bank Economic Review 14*(2), 251–285.

Aguiar, M. and G. Gopinath (2007). Emerging Market Business Cycles: The Cycle Is the Trend. *Journal of Political Economy 115*, 69–102.

Akinboade, O. A. and D. Makina (2010). Econometric analysis of bank lending and business cycles in south africa. *Applied Economics 42*(29), 3803–3811.

Alpanda, S., K. Kotzé, and G. Woglom (2010). The role of the exchange rate in a new keynesian dsge model for the south african economy. *South African Journal of Economics 78*, 170–191.

Alpanda, S., K. Kotzé, and G. Woglom (2011). Forecasting Performance Of An Estimated Dsge Model For The South African Economy. *South African Journal of Economics 79*(1), 50–67.

Anand, R., S. Kothari, and N. Kumar (2016). South africa : Labor market dynamics and inequality. Technical report, IMF Working Paper No. 16/137.

Anand, R., E. S. Prasad, and B. Zhang (2015). What measure of inflation should a developing country central bank target? *Journal of Monetary Economics 74*(C), 102–116.

Andrle, M. (2010). A note on identification patterns in DSGE models. Working Paper Series 1235, European Central Bank.

Arellano, C. and E. G. Mendoza (2002, April). Credit Frictions and 'Sudden Stops' in Small Open Economies: An Equilibrium Business Cycle Framework for Emerging Markets Crises. NBER Working Papers 8880, National Bureau of Economic Research, Inc.

Armstrong, P. and J. Steenkamp (2008). South African Trade Unions: an Overview for 1995 to 2005. Working Papers 10/2008, Stellenbosch University, Department of Economics.

Aron, J. and J. Muellbauer (2002). Estimating Monetary Policy Rules for South Africa. In N. Loayza, K. Schmidt-Hebbel, N. L. S. Editor), and K. S.-H. (Series (Eds.), *Monetary Policy: Rules and Transmission Mechanisms*, Volume 4 of *Central Banking, Analysis, and Economic Policies Book Series*, Chapter 15, pp. 427–476. Central Bank of Chile.

Aron, J. and J. Muellbauer (2006). Review of monetary policy in south africa since 1994. CSAE Working Paper Series 2006-07, Centre for the Study of African Economies, University of Oxford.

Atkeson, A. and C. Phelan (1994). Reconsidering the Costs of Business Cycles with Incomplete Markets. In *NBER Macroeconomics Annual 1994, Volume 9*, NBER Chapters, pp. 187–218. National Bureau of Economic Research, Inc.

Atta-Mensah, J. and A. Dib (2008). Bank lending, credit shocks, and the transmission of canadian monetary policy. *International Review of Economics & Finance 17*(1), 159–176.

Banerjee, A., S. Galiani, J. Levinsohn, Z. McLaren, and I. Woolard (2008). Why has unemployment risen in the New South Africa? *The Economics of Transition 16*(4), 715–740.

Barlevy, G. (2004). The Cost of Business Cycles and the Benefits of Stabilization: A Survey. NBER Working Papers 10926, National Bureau of Economic Research, Inc.

Beaudry, P. and C. Pages (2001). The cost of business cycles and the stabilization value of unemployment insurance. *European Economic Review 45*(8), 1545 – 1572.

Benigno, P. and M. Woodford (2005). Inflation Stabilization And Welfare: The Case Of A Distorted Steady State. *Journal of the European Economic Association 3*(6), 1185–1236.

Benigno, P. and M. Woodford (2012). Linear-quadratic approximation of optimal policy problems. *Journal of Economic Theory 147*(1), 1–42.

Bernanke, B. S., M. Gertler, and S. Gilchrist (1999). The financial accelerator in a quantitative business cycle framework. In J. B. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics*, Volume 1 of *Handbook of Macroeconomics*, Chapter 21, pp. 1341–1393. Elsevier.

Bewley, T. F. (1999). *Why wages do not fall during a recession?* Harvard University Press.

Bhattacharya, R. and I. Patnaik (2016). Financial Inclusion, Productivity Shocks, and Consumption Volatility in Emerging Economies. *World Bank Economic Review 30*(1), 171–201.

Bhorat, H., S. Goga, and D. Tseng (2013). Unemployment Insurance in South Africa: A Descriptive Overview of Claimants and Claims. Working Papers 13160, University of Cape Town, Development Policy Research Unit.

Bhorat, H., S. Goga, and C. van der Westhuizen (2009). Analysing wage formation in the south african labour market: The role of bargaining councils. *SSRN Electronic Journal*.

Bhorat, H., S. Goga, and C. V. D. Westhuizen (2012). Institutional Wage Effects: Revisiting Union And Bargaining Council Wage Premia In South Africa. *South African Journal of Economics 80*(3), 400–414.

Bhorat, H., K. Naidoo, and D. Yu (2014). Trade Unions In An Emerging Economy: The Case Of South Africa. Working Papers 201402, University of Cape Town, Development Policy Research Unit.

Bilbiie, F. O. (2008). Limited asset markets participation, monetary policy and (inverted) aggregate demand logic. *Journal of Economic Theory 140*(1), 162–196.

Bilbiie, F. O. and X. Ragot (2017). Inequality, Liquidity, and Optimal Monetary Policy. CEPR Discussion Papers 11814, C.E.P.R. Discussion Papers.

Breen, R. and C. García-Peñalosa (2005). Income Inequality and Macroeconomic Volatility: An Empirical Investigation. *Review of Development Economics 9*(3), 380–398.

Broda, C. (2004). Terms of trade and exchange rate regimes in developing countries. *Journal of International Economics 63*(1), 31–58.

Brzoza-Brzezina, M. and J. Kotlowski (2016). The nonlinear nature of country risk and its implications for DSGE models. NBP Working Papers 250, Narodowy Bank Polski, Economic Research Department.

Burstein, A., C. Kurz, and L. Tesar (2008). Trade, production sharing, and the international transmission of business cycles. *Journal of Monetary Economics 55*(4), 775–795.

Calvo, G. A. and C. M. Reinhart (2002). Fear of Floating. *The Quarterly Journal of Economics 117*(2), 379–408.

Cantore, C., M. León-Ledesma, P. McAdam, and A. Willman (2014). Shocking Stuff: Technology, Hours, And Factor Substitution. *Journal of the European Economic Association 12*(1), 108–128.

Cantore, C. and P. Levine (2012). Getting normalization right: Dealing with "dimensional constants" in macroeconomics. *Journal of Economic Dynamics and Control 36*(12), 1931–1949.

Cardi, O. and R. Restout (2015). Imperfect mobility of labor across sectors: a reappraisal of the Balassa Samuelson effect. *Journal of International Economics 97*(2), 249–265.

Cashin, P. (2004). Caribbean Business Cycles. IMF working papers 04/136, International Monetary Fund.

Cetorelli, N. and L. S. Goldberg (2011). Global Banks and International Shock Transmission: Evidence from the Crisis. *IMF Economic Review 59*(1), 41–76.

Chia, W.-M. and J. D. Alba (2006, 09). Terms-of-trade shocks and exchange rate regimes in a small open economy. *The Economic Record 82*(s1), S41–S53.

Cho, J.-O., T. Cooley, and H. S. Kim (2015). Business Cycle Uncertainty and Economic Welfare. *Review of Economic Dynamics 18*(2), 185–200.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy 113*(1), 1–45.

Claessens, S. and N. Horen (2014). Foreign Banks: Trends and Impact. *Journal of Money, Credit and Banking 46*(s1), 295–326.

Clarida, R., J. Gali, and M. Gertler (1999). The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature 37*(4), 1661–1707.

Coenen, G. and R. Straub (2005). Non-Ricardian Households and Fiscal Policy in an Estimated DSGE Model of the Euro Area. Computing in Economics and Finance 2005 102, Society for Computational Economics.

Cúrdia, V. and M. Woodford (2016). Credit Frictions and Optimal Monetary Policy. *Journal of Monetary Economics 84*(C), 30–65.

Crucini, M., A. Kose, and C. Otrok (2011). What are the driving forces of international business cycles? *Review of Economic Dynamics 14*(1), 156–175.

Céspedes, L. F., J. Fornero, and J. Galí (2012). Non-ricardian aspects of fiscal policy in chile. Working Papers Central Bank of Chile 663, Central Bank of Chile.

Dagher, J., J. Gottschalk, and R. Portillo (2010). Oil windfalls in ghana: A dsge approach. IMF Working Papers 10/116, International Monetary Fund.

Deaton, A. and R. Miller (1996). International commodity prices, macroeconomic performance and politics in sub-saharan africa. *Journal of African Economies 5*(3), 99–191.

DeJong, D., B. Ingram, and C. Whiteman (2000). A bayesian approach to dynamic macroeconomics. *Journal of Econometrics 98*(2), 203–223.

Devereux, M. B., P. R. Lane, and J. Xu (2006). Exchange Rates and Monetary Policy in Emerging Market Economies. *Economic Journal 116*(511), 478–506.

Dolmas, J. (1998). Risk Preferences and the Welfare Cost of Business Cycles. *Review of Economic Dynamics 1*(3), 646–676.

Doz, C., D. Giannone, and L. Reichlin (2011). A two-step estimator for large approximate dynamic factor models based on Kalman filtering. *Journal of Econometrics 164*(1), 188–205.

Drechsel, T. and S. Tenreyro (2017). Commodity Booms and Busts in Emerging Economies. In *NBER International Seminar on Macroeconomics 2017*, NBER Chapters. National Bureau of Economic Research, Inc.

du Plessis, S. (2006). Business Cycles in Emerging market Economies: A New View of the Stylised Facts. Working Papers 02/200, Stellenbosch University, Department of Economics.

du Plessis, S., B. Smit, and R. Steinbach (2014). A medium scale dsge model of the south african economy. Technical report, SA Reserve Bank Discussion Paper 14-01.

Engel, C. (2011). Currency Misalignments and Optimal Monetary Policy: A Reexamination. *American Economic Review 101*(6), 2796–2822.

Epstein, L. G. and S. E. Zin (1989). Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework. *Econometrica 57*(4), 937–969.

Erceg, C. J., L. Guerrieri, and C. Gust (2006). SIGMA: A New Open Economy Model for Policy Analysis. *International Journal of Central Banking 2*(1).

Erceg, C. J., D. W. Henderson, and A. T. Levin (2000). Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics 46*(2), 281–313.

Fedderke, J. (2012). The Cost of Rigidity: The Case of the South African Labor Market. *Comparative Economic Studies 54*(4), 809–842.

Fernandez, A., A. Gonzalez, and D. Rodriguez (2015). Sharing a Ride on the Commodities Roller Coaster; Common Factors in Business Cycles of Emerging Economies. IMF Working Papers 15/280, International Monetary Fund.

Fernández, A., S. Schmitt-Grohé, and M. Uribe (2017). World shocks, world prices, and business cycles: An empirical investigation. *Journal of International Economics 108*(S1), 2–14.

Frankel, J. (2011). Monetary Policy in Emerging Markets: A Survey. Working Paper Series rwp11-003, Harvard University, John F. Kennedy School of Government.

Galí, J., J. D. López-Salido, and J. Vallés (2007). Understanding the Effects of Government Spending on Consumption. *Journal of the European Economic Association 5*(1), 227–270.

Gali, J. (1994). Keeping Up with the Joneses: Consumption Externalities, Portfolio Choice, and Asset Prices. *Journal of Money, Credit and Banking 26*(1), 1–8.

Gali, J. and T. Monacelli (2005). Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *Review of Economic Studies 72*(3), 707–734.

Garcia-Cicco, J., R. Pancrazi, and M. Uribe (2010). Real Business Cycles in Emerging Countries? *American Economic Review 100*(5), 2510–2531.

Gerali, A., S. Neri, L. Sessa, and F. M. Signoretti (2010). Credit and Banking in a DSGE Model of the Euro Area. *Journal of Money, Credit and Banking 42*(s1), 107–141.

Gertler, M. and A. Trigari (2009). Unemployment Fluctuations with Staggered Nash Wage Bargaining. *Journal of Political Economy 117*(1), 38–86.

Giannone, D., L. Reichlin, and D. Small (2008). Nowcasting: The real-time informational content of macroeconomic data. *Journal of Monetary Economics 55*(4), 665–676.

Gilchrist, S., V. Yankov, and E. Zakrajsek (2009). Credit market shocks and economic fluctuations: Evidence from corporate bond and stock markets. *Journal of Monetary Economics 56*(4), 471–493.

Godfrey, S., J. Theron, and M. Visser (2007). The State of Collective Bargaining in South Africa: An Empirical and Conceptual Study of Collective Bargaining. Working Papers 07130, University of Cape Town, Development Policy Research Unit.

Gomes, J., J. Greenwood, and S. Rebelo (2001). Equilibrium unemployment. *Journal of Monetary Economics 48*(1), 109–152.

Gupta, R. and R. Steinbach (2013). A DSGE-VAR model for forecasting key South African macroeconomic variables. *Economic Modelling 33*(C), 19–33.

Hall, R. E. (2005). Employment Fluctuations with Equilibrium Wage Stickiness. *American Economic Review 95*(1), 50–65.

Harding, D. and A. Pagan (2002). Dissecting the cycle: a methodological investigation. *Journal of Monetary Economics 49*(2), 365–381.

Hausmann, R., U. Panizza, and E. Stein (2001). Why do countries float the way they float? *Journal of Development Economics 66*(2), 387–414.

Helbling, T., R. Huidrom, M. A. Kose, and C. Otrok (2011). Do credit shocks matter? a global perspective. *European Economic Review 55*(3), 340–353.

Hoffmaister, A. W., J. E. Roldos, and P. Wickham (1998). Macroeconomic fluctuations in sub-saharan africa. *IMF Staff Papers 45*(1), 132–160.

Hoffmaister, A. W. and J. Roldós (1997). Are business cycles different in asia and latin america. IMF working papers 97/9, International Monetary Fund.

Horvath, M. (2000). Sectoral shocks and aggregate fluctuations. *Journal of Monetary Economics 45*(1), 69–106.

Houssa, R. (2008). Monetary union in west africa and asymmetric shocks: A dynamic structural factor model approach. *Journal of Development Economics 85*(1-2), 319–347.

Houssa, R. (2009). Asymmetric shocks in the west african monetary union. Research paper 187, African Economic Research Consortium.

Houssa, R. (2013). Uncertainty about welfare effects of consumption fluctuations. *European Economic Review 59*(C), 35–62.

Houssa, R., J. Mohimont, and C. Otrok (2013). Credit Shocks and Macroeconomic Fluctuations in Emerging Markets. CESifo Working Paper Series 4281, CESifo Group Munich.

Houssa, R., J. Mohimont, and C. Otrok (2015). Sources of business cycles in a low income country. *Pacific Economic Review 20*(1), 125–148.

Houssa, R., J. Mohimont, and C. Otrok (2018). Empirical framework for macroeconomic policies in emerging markets. Technical report, University of Namur.

Houssa, R., C. Otrok, and R. Puslenghea (2010). A model for monetary policy analysis for sub-saharan africa. *Open Economies Review 21*, 127–145.

Hove, S., A. Touna Mama, and F. Tchana Tchana (2015). Monetary policy and commodity terms of trade shocks in emerging market economies. *Economic Modelling 49*(C), 53–71.

Iacoviello, M. (2005). House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle. *American Economic Review 95*(3), 739–764.

Imrohoruglu, A. (1989). Cost of Business Cycles with Indivisibilities and Liquidity Constraints. *Journal of Political Economy 97*(6), 1364–1383.

Ireland, P. N. (1997). A small, structural, quarterly model for monetary policy evaluation. *Carnegie-Rochester Conference Series on Public Policy 47*, 83 – 108.

Iskrev, N. (2010). Local identification in DSGE models. *Journal of Monetary Economics 57*(2), 189–202.

Iyer, T. (2016). Optimal Monetary Policy in an Open Emerging Market Economy. Working Paper Series WP-2016-6, Federal Reserve Bank of Chicago.

Justiniano, A. and B. Preston (2010). Can structural small open-economy models account for the influence of foreign disturbances? *Journal of International Economics 81*(1), 61–74.

Kilian, L. (2009). Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market. *American Economic Review 99*(3), 1053–1069.

Klein, N. (2012). Real wage, labor productivity, and employment trends in south africa : A closer look. Technical report, IMF Working Paper No. 12/92.

Klein, P. (2000). Using the generalized Schur form to solve a multivariate linear rational expectations model. *Journal of Economic Dynamics and Control 24*(10), 1405–1423.

Kollmann, R. (2002). Monetary policy rules in the open economy: effects on welfare and business cycles. *Journal of Monetary Economics 49*(5), 989–1015.

Kollmann, R. (2013). Global Banks, Financial Shocks, and International Business Cycles: Evidence from an Estimated Model. *Journal of Money, Credit and Banking 45*(s2), 159–195.

Kose, M. A. (2002). Explaining business cycles in small open economies: 'how much do world prices matter?'. *Journal of International Economics 56*(2), 299–327.

Kose, M. A. and R. Riezman (2001). Trade shocks and macroeconomic fluctuations in africa. *Journal of Development Economics 65*(1), 55–80.

Krebs, T. (2007). Job Displacement Risk and the Cost of Business Cycles. *American Economic Review 97*(3), 664–686.

Krusell, P., T. Mukoyama, A. Sahin, and J. Anthony A. Smith (2009). Revisiting the Welfare Effects of Eliminating Business Cycles. *Review of Economic Dynamics 12*(3), 393–402.

Krusell, P. and A. A. Smith (1999). On the welfare effects of eliminating business cycles. *Review of Economic Dynamics 2*(1), 245 – 272.

Lane, P. R. and G. M. Milesi-Ferretti (2007). The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970-2004. *Journal of International Economics 73*(2), 223–250.

Leitemo, K. and U. Soderstrom (2005). Simple monetary policy rules and exchange rate uncertainty. *Journal of International Money and Finance 24*(3), 481–507.

Lester, R., M. Pries, and E. Sims (2014). Volatility and welfare. *Journal of Economic Dynamics and Control 38*(Supplement C), 17 – 36.

Levy, P. I. (1999). Sanctions on south africa: What did they do? *The American Economic Review 89*(2), 415–420.

Liu, G. D., R. Gupta, and E. Schaling (2009). A New-Keynesian DSGE model for forecasting the South African economy. *Journal of Forecasting 28*(5), 387–404.

Loayza, N. V., R. Rancière, L. Servén, and J. Ventura (2007). Macroeconomic Volatility and Welfare in Developing Countries: An Introduction. *World Bank Economic Review 21*(3), 343–357.

Lubik, T. A. and F. Schorfheide (2007). Do central banks respond to exchange rate movements? A structural investigation. *Journal of Monetary Economics 54*(4), 1069–1087.

Lucas, R. (1987). Models of Business Cycles. *Oxford: Basil Blackwell.*

Lucas, R. (2003). Macroeconomic Priorities. *American Economic Review 93*(1), 1–14.

Magruder, J. R. (2012). High Unemployment Yet Few Small Firms: The Role of Centralized Bargaining in South Africa. *American Economic Journal: Applied Economics 4*(3), 138–166.

Male, R. (2011). Developing Country Business Cycles: Characterizing the Cycle. *Emerging Markets Finance and Trade 47*(0), 20–39.

Mankiw, N. G. (2000). The Savers-Spenders Theory of Fiscal Policy. *American Economic Review 90*(2), 120–125.

Medina, J. P. and C. Soto (2007). The chilean business cycles through the lens of a stochastic general equilibrium model. Working Papers Central Bank of Chile 457, Central Bank of Chile.

Meeks, R. (2012). Do credit market shocks drive output fluctuations? evidence from corporate spreads and defaults. *Journal of Economic Dynamics and Control 36*(4), 568–584.

Mendoza, E. G. (1995). The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations. *International Economic Review 36*(1), 101–37.

Mendoza, E. G. (2002). Credit, Prices, and Crashes: Business Cycles with a Sudden Stop. In *Preventing Currency Crises in Emerging Markets*, NBER Chapters, pp. 335–392. National Bureau of Economic Research, Inc.

Mohanty, M. S. and M. Klau (2004). Monetary policy rules in emerging market economies: issues and evidence. BIS Working Papers 149, Bank for International Settlements.

Mollentze, S. (2000). Monetary Policy in South Africa on the Threshold of a New Era. *South African journal of economic and management sciences: Supplement series (No 2)*.

Mortensen, D. T. and C. A. Pissarides (1994). Job Creation and Job Destruction in the Theory of Unemployment. *Review of Economic Studies 61*(3), 397–415.

Mountford, A. and H. Uhlig (2009). What are the effects of fiscal policy shocks? *Journal of Applied Econometrics 24*(6), 960–992.

Muyambiri, B. and N. Odhiambo (2014). A chronological analysis of monetary policy and the financial system in South Africa. *Public and Municipal Finance*.

Naceur, S. B. and R. Zhang (2016). Financial Development, Inequality and Poverty; Some International Evidence. IMF Working Papers 16/32, International Monetary Fund.

Neumeyer, P. A. and F. Perri (2005). Business cycles in emerging economies: the role of interest rates. *Journal of Monetary Economics 52*(2), 345 – 380.

Nisticò, S. (2016). Optimal Monetary Policy And Financial Stability In A Non-Ricardian Economy. *Journal of the European Economic Association 14*(5), 1225–1252.

Obstfeld, M. (1994). Evaluating risky consumption paths: The role of intertemporal substitutability. *European Economic Review 38*(7), 1471–1486.

Ortiz, A. and F. Sturzenegger (2007). Estimating Sarb'S Policy Reaction Rule. *South African Journal of Economics 75*(4), 659–680.

Otrok, C. (2001). On measuring the welfare cost of business cycles. *Journal of Monetary Economics 47*(1), 61–92.

Pallage, S. and M. Robe (2003). On the welfare cost of economic fluctuations in developing countries. *International Economic Review 44*(2), 677–698.

Park, C.-Y. and R. Mercado (2015). Financial Inclusion, Poverty, and Income Inequality in Developing Asia. ADB Economics Working Paper Series 426, Asian Development Bank.

Peters, A. C. (2016). Monetary policy, exchange rate targeting and fear of floating in emerging market economies. *International Economics and Economic Policy 13*(2), 255–281.

Prasad, E. and B. Zhang (2015). Distributional Effects of Monetary Policy in Emerging Market Economies. NBER Working Papers 21471, National Bureau of Economic Research, Inc.

Raddatz, C. (2007). Are external shocks responsible for the instability of output in low-income countries? *Journal of Development Economics 84*(1), 155–187.

Ranchhod, V. (2013). Earnings volatility in south africa. Technical report, NIDS Discussion Paper 2013/3.

Rand, J. and F. Tarp (2002). Business Cycles in Developing Countries: Are They Different? *World Development 30*(12), 2071–2088.

Ratto, M., W. Roeger, and J. i. t. Veld (2009). QUEST III: An estimated open-economy DSGE model of the euro area with fiscal and monetary policy. *Economic Modelling 26*(1), 222–233.

Rotemberg, J. and M. Woodford (1997). An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy. In *NBER Macroeconomics Annual 1997, Volume 12*, NBER Chapters, pp. 297–361. National Bureau of Economic Research, Inc.

Rotemberg, J. J. and M. Woodford (1999). Interest Rate Rules in an Estimated Sticky Price Model. In *Monetary Policy Rules*, NBER Chapters, pp. 57–126. National Bureau of Economic Research, Inc.

Santis, M. D. (2007). Individual Consumption Risk and the Welfare Cost of Business Cycles. *American Economic Review 97*(4), 1488–1506.

Schmitt-Grohé, S. and M. Uribe (2006). Optimal fiscal and monetary policy in a medium-scale macroeconomic model. Working Paper Series 0612, European Central Bank.

Schmitt-Grohé, S. and M. Uribe (2015). How Important Are Terms Of Trade Shocks? CEPR Discussion Papers 10655, C.E.P.R. Discussion Papers.

Schmitt-Grohe, S. and M. Uribe (2003). Closing small open economy models. *Journal of International Economics 61*(1), 163–185.

Schmitt-Grohe, S. and M. Uribe (2004). Solving dynamic general equilibrium models using a second-order approximation to the policy function. *Journal of Economic Dynamics and Control 28*(4), 755–775.

Schmitt-Grohe, S. and M. Uribe (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics 54*(6), 1702–1725.

Schnabl, P. (2012). The international transmission of bank liquidity shocks: Evidence from an emerging market. *Journal of Finance 67*(3), 897–932.

Schorfheide, F. (2000). Loss function-based evaluation of DSGE models. *Journal of Applied Econometrics 15*(6), 645–670.

Sims, C. A. (2002). Solving Linear Rational Expectations Models. *Computational Economics 20*(1-2), 1–20.

Smets, F. and R. Wouters (2007). Shocks and frictions in us business cycles: a bayesian dsge approach. Working Paper Series 0722, European Central Bank.

Smit, B., C. Grobler, and C. Nel (2014). Sudden stops and current account reversals: Potential macroeconomic consequences for south africa. *South African Journal of Economics 82*(4), 616–627.

Sowa, N. K. and I. K. Acquaye (1999). Financial and foreign exchange markets liberalization in Ghana. *Journal of International Development 11*(3), 385–409.

Steinbach, M., P. Mathuloe, and B. Smit (2009). An open economy new keynesian dsge model of the south african economy. *South African Journal of Economics 77*(2), 207–227.

Storesletten, K., C. I. Telmer, and A. Yaron (2001). The welfare cost of business cycles revisited: Finite lives and cyclical variation in idiosyncratic risk. *European Economic Review 45*(7), 1311–1339.

Tallarini, T. (2000). Risk-sensitive real business cycles. *Journal of Monetary Economics 45*(3), 507–532.

Tamasi, B. and B. Vilagi (2011). Identification of credit supply shocks in a bayesian svar model of the hungarian economy. MNB Working Papers 2011/7, Magyar Nemzeti Bank (The Central Bank of Hungary).

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy 39*(1), 195–214.

Temple, J. (2012). The calibration of CES production functions. *Journal of Macroeconomics 34*(2), 294–303.

Thomas, C. (2008). Search and matching frictions and optimal monetary policy. *Journal of Monetary Economics 55*(5), 936–956.

Turégano, D. M. and A. G. Herrero (2018). Financial Inclusion, Rather Than Size, Is The Key To Tackling Income Inequality. *The Singapore Economic Review (SER) 63*(01), 167–184.

Uhlig, H. (1995). A toolkit for analyzing nonlinear dynamic stochastic models easily. Discussion Paper / Institute for Empirical Macroeconomics 101, Federal Reserve Bank of Minneapolis.

Uhlig, H. (2005). What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics 52*(2), 381–419.

UNCTAD (2016). The State of Commodity Dependence. Technical report, United Nations Conference on Trade And Development.

von Fintel, D. (2016). Wage flexibility in a high unemployment regime: spatial heterogeneity and the size of local labour markets. Working Papers 09/2016, Stellenbosch University, Department of Economics.

von Fintel, D. (2017). Institutional wage-setting, labour demand and labour supply: Causal estimates from a South African pseudo-panel. *Development Southern Africa 34*(1), 1–16.

Wu, J. C. and F. D. Xia (2016). Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound. *Journal of Money, Credit and Banking 48*(2-3), 253–291.